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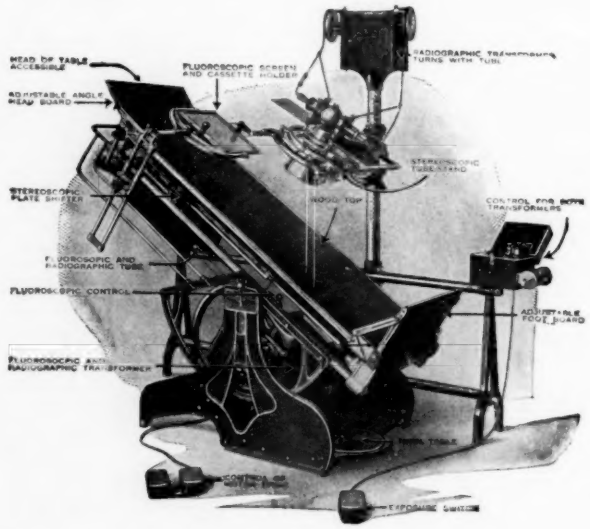


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# THE *X*-RAY DIAGNOSIS OF ACCESSORY SINUSITIS*

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THE examination and interpretation of roentgenograms of the pneumatic structures of the head are beset with so many difficulties that the method has never enjoyed the wide application that it deserves. Much serious study has been applied to this field and there are numerous publications on the subject. Many special positions and projections have been proposed, and in the hands of experts these are undoubtedly of great value. The beginner, however, is apt to be confused by all this, and, after all is said and done, the surgeon and the internist are not impressed with the authority of the average roentgenographer and pay scant attention to his opinions.

This paper was undertaken in the hope that some improvement in this situation might result through the application of old principles rather than through the contribution of anything essentially new, and through the adoption of a simpler but more comprehensive routine technique.

## TECHNICAL DISCUSSION

After struggling for some time with the methods available and in the face of an unsympathetic surgeon, we took stock of the situation and drew up the following requirements as essential to accurate judgment.

1. The structures of the nose and of all the sinuses should be demonstrated at a single routine examination.

2. Opportunity should be offered for the direct comparison of symmetrical parts.

3. Since the confusing shadows of the structures of the base of the skull and the cervical spine cannot be obviated by any one position or projection, sufficient differentiation of these structures should be offered so that their shadows may be recognized and separately appreciated and evaluated.

We believe these requirements are very nearly met by the technique that was finally adopted. While not new in any particular, we wish to lay emphasis on certain features that we believe important. It provides for a strictly sagittal projection, covers all of the region under examination at one time, demonstrates satisfactorily the structures of the nose, and depends on stereoscopic vision to differentiate the petrous portions of the temporals and the cervical spine and to lift them out of the region that is the subject of special study. This differentiation depends on the sharpest possible definition and this can be attained only by using a very small focus spot at a considerable distance and with a narrow cone. Further, we aim to project the petrous portions of the temporals into the lower portions of the orbits where their shadows will nicely dovetail with those of the butterfly-shaped ethmoid labyrinth without serious overlapping of shadows.

* Read at the Twenty-second Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Washington, D. C., Sept. 27–30, 1921.

Everything depends on the fineness of the detail in the posterior portion of the field. This, we believe, can be accomplished only by the use of the fine focus radiator type tube. In our experience the 30 ma. tube will not do. The broader focus spot increases the width of the penumbra—to borrow an optical expression—"the circle of confusion" is too large. Theoretically, an improvement in the definition may be produced by increasing the focus-plate distance. But one loses all the advantages of the greater capacity of the tube in the added energy requirement, and an identical exposure time is necessary.

Our practice is to use the 10 ma. radiator type tube, loaded to 8 ma. under a tension equivalent to about a 5½ or 6 inch back-up spark. A long cone with small diaphragm is employed providing a circle of illumination on the plate not exceeding 5 inches in diameter. The patient lies prone with the forehead in contact with the plate changer, which is inclined at an angle of 22 degrees from the horizontal. The position of the focus spot in the sagittal plane is determined by a line passing from a point just below the outer canthus of the eye through the external auditory meatus and upwards. The head is fixed by a thin pad of cotton, this is in turn covered by an aluminum hemisphere and held in place by the pressure of the cone which is lowered upon it. The exposure time is approximately 240 ma.s. For the second plate of the stereo set the tube is moved cephalad 2½ or 3 inches.

A slight deviation from the strictly sagittal position is not so serious in the individual with a well-rounded neck, but many individuals have necks that are far from circular in cross section and under such circumstances the extra shadows of the soft tissues projected to one side produce serious confusion. Such oblique projection is further apt to cover the more lateral of the posterior ethmoids with the shadow of the processus pyramidalis. Sagittal projection on both plates is very important.

The importance of the small focus spot cannot be over-emphasized. Upon it depends the greater "depth of focus," if I may borrow another optical expression, and this "depth of focus" is the fundamental basis of the superior stereoscopic image of the plates made by this technique. The ordinary practice aims principally at a sharp focus only in those structures in which one is primarily interested and attempts to bring them into definition by placing them close to the plates. It then attempts to remove the bothersome shadows from behind by oblique projection. We, however, depend rather on lifting them out of the way by the superior stereoscopic vision made possible by the greater definition in the objectionable overriding shadows.

Stereoscopic vision depends directly on the sharpness of definition. It consists in the subconscious summation of innumerable triangulations, each based on some sharply defined point. In the absence of such fine points, stereoscopic vision fails, and in the presence of only a few poorly defined points, the image is correspondingly indefinite. The further back in the skull we can carry the requisite definition the less trouble we shall have with the confusion caused by overlying shadows. The eye and the visual centers will then subconsciously evaluate the densities traversed by the visual rays and leave the attention free to estimate the densities of the structures in which we are primarily concerned.

In this connection it should be noted that the tube shift in the sagittal plane of the body contributes in no small degree to the sense of depth in the stereo image. It is, I believe, a well-recognized principle that undifferentiated lines running in the horizontal direction across the field of vision cannot be located with reference to their depth and therefore the general rule that the tube shift must always be carried "across the principal lines of the picture." It so happens that the structures that we are most anxious to place accurately, viz., the floor of the anterior fossa, the sphenoid, the tegmen of the petrosal, the condyles of the occiput, the lateral bodies and the transverse processes of the cervical vertebrae, are all better differentiated along horizontal lines. It is fortunate that the longitudinal tube-shift also gives a rigidly

sagittal projection on both plates of the stereoscopic set.

However, the physical limitations of the tube leave us considerably short of the perfect plate and we are obliged to exercise considerable care to place the most conspicuous and troublesome shadows (those of the petrous portion of the temporals) where they will cause the least confusion, viz., in the lower portion of the orbits.

We demand that our plates shall show clearly and in good stereoscopic vision the lateral processes of the atlas and axis and the tip of the odontoid process. The latter should lie in the mid-line and should not reach above the lower third of the septum of the nose. It is necessary to recognize clearly the structures of the upper nasal passages as well, if one is to judge of the associated conditions in the sinuses.

It is not necessary to catalogue the large number of other structures that one can recognize. The list grows longer as we see more and more plates.

The position here advocated necessarily throws the long axis of the ethmoid labyrinth almost directly in the line of vision and superimposes the posterior ethmoid shadows on the anterior group. This is the most frequently heard objection to this technique. Here again we depend on the greater brilliancy of the stereoscopic image to distinguish the position of the shadows which we believe abnormal. This is the more feasible, because, as I expect to show later, we depend for our interpretation on the changes in the bony structures more than on the hazy opacities that are caused by the exudates and the soft tissue changes in the diseased pneumatic cells. The frontal sinuses are not spread over so wide an area as in the other positions, but this objection is more than compensated by the superior view one obtains of the infundibulum and the associated ethmoid cells of the anterior group. We have experienced little difficulty in recognizing disease in this neighborhood since adopting the technique described.

## PATHOLOGY

All that we know of the clinical history, the etiology, and the pathological sequences in chronic sinus infections teaches that they are complications or sequelae of disease processes that have their inception in the nose or teeth. When the accessory sinuses become involved in an acute inflammatory process extending from either of these points, healing is prompt and complete unless there are causes in the nose prolonging the infection. In the normal sinus there is little tendency to chronicity. It is only when structural changes in the turbinates, in the septum, or in the mucosa of the nose interfere with the proper drainage and aeration of the sinuses or constantly supply fresh accretions of infective materials to the sinuses that the latter fail to recover.

Perhaps the most common sequence is something like this: A primary deviation of the septum, secondary and to some degree compensatory hypertrophy and atrophy of the turbinates, contacts, spurs, and consecutive changes in the nasal mucosa, occlusion of the ostia of the sinuses by swelling of the mucous membrane and finally, infection of the accessory structures of the labyrinth.

The discovery of any one of these changes in the roentgenogram of the nose therefore has an important bearing on the diagnosis of the condition of the sinuses and we need not be entirely dependent on the rhinologist for their demonstration. Many of them can be clearly recognized on the *x*-ray plate. Therefore, the nose deserves as much attention as the sinuses and reliable judgment can only be based on a consideration of the entire related region as a whole.

The first effect of an acute infection of the sinuses is seen in the hyperemia, edema, and cellular and fluid exudates within the mucous membrane and on the surface. The nature and extent of these changes probably vary as do those in the mucosa of the nasal cavity with the nature of the virus and the virulence of the infection. To the roentgenologist, the cells should appear denser than normal through the replacement of the normally contained air by a denser material.

With a greater duration of the process, rather divergent processes appear, depending on factors with which we are not entirely familiar. On the one hand, the process may become frankly purulent,

the mucous membrane become atrophic, the submucous layers become sclerotic, and through the irritation of the periosteal layers of the submucosa, extensive sclerosis and osteoplastic changes result in the bony septa and walls of the sinuses. These processes are extended by continuity along the bony structures of the lateral walls of the nose to the origins of the turbinates, causing hypertrophies and increased densities. These in turn encroach upon the air spaces of the nose and by their deformities and the attendant hypertrophies of their mucous membranes interfere with the drainage of the sinuses and establish a vicious circle. The formation of polyps at the points of greatest irritation by the escaping exudates further complicates the situation and tends to maintain the inflammation in the sinuses.

On the other hand, the changes in the mucous lining of the sinuses may take the form of an extensive edema, with a hypertrophy of the lymphoid elements and the mucous cells of the membrane leading to the so-called polypoid degeneration. The effect upon the underlying bony tissue is not that of an osteoplastic but an osteoclastic and osteoporotic change—the septa lose their lime salts and appear to shrink. These changes also are transmitted to the adjacent nasal structures with a corresponding reduction in the density and size of the turbinates. In the cases of the upper and middle turbinates the mucosa is usually reduced in thickness and in density. The effect on the *x*-ray plate is therefore the entire occlusion of the upper nasal passages with an abnormally free space below the level of the lower margin of the middle turbinates.

The differences in the histological pictures within the sinuses are well summarized by Skillern on the following counts:

1. The purulent type shows a general metaplasia of the ciliated epithelium where it comes in contact with the secretions; the hypertrophic type shows such changes only at points of pressure or contact.

2. The purulent type shows a sclerosis of the submucous connective tissues; the hypertrophic shows a dilation of its meshes and lymph spaces.

3. The purulent type shows extensive round cell infiltration; the hypertrophic does not.

4. The purulent type produces a primary atrophy of the glands; the hypertrophic type produces a hypertrophy of these structures.

5. The purulent type leads to deposition of bony tissue in the subperiosteal layer; the hypertrophic leads to osteoporosis.

This last item is of supreme interest to the roentgenologist.

While polyps occur in both types of disease, they are largely confined to the intranasal structures in the purulent type of the disease, while the entire ethmoid labyrinth and the maxillary sinuses are usually filled with large masses of these structures in the hypertrophic type. For this reason, it is usual to speak of the latter as "polypoid disease." We greatly prefer this designation because of the contradiction between the predominant *x*-ray findings and the descriptive content of the adjective "hypertrophic."

On clinical grounds the nasal surgeon also recognizes these two types of chronic infection of the accessory sinuses. This classification is apparently made principally on the changes in the mucosa and the nature of the exudate found in the cavities of the sinuses.

The purulent type is distinguished clinically by a distribution limited to one or a few related cavities, by deformities of the septum and hypertrophies of the turbinates, the occurrence of a few polyps about the ostia of the sinuses and the escape of free pus from their interior. The latter feature is the principal evidence on which the surgeon bases his diagnosis.

The hypertrophic or polypoid type has a more widespread distribution; it is less commonly associated with deformities of the septum, shows atrophy instead of hypertrophy of the lower turbinates, involving the bony as well as the soft tissue elements of these structures; but the outstanding feature of many cases is the extensive degeneration of the mucosa of the upper nasal passages and of the accessory sinuses. The picture within the nose is often that of an "atrophic rhinitis."

The above statement that polypoid

disease is usually widely distributed is at variance with the usual texts. For instance, the best text at hand makes the following statement:

"While pansinusitis of one side is uncommonly met with, that where all the sinuses are simultaneously involved belongs to the greatest rarity."

My experience is that true polypoid disease is more commonly general than limited in distribution. I recall very few cases that were not symmetrical in distribution, and while under such circumstances the demonstration of the completeness of the involvement is obviously difficult, my impression is that incomplete involvement is the exception. Not unusually the maxillaries seem to be less extensively diseased, but this may represent merely an earlier stage of the disease. Except for this, no clear stages of the disease have come to my notice. Partial or limited involvements which might be interpreted as chronological stages of the disease are rare and of questionable significance. Once the ethmoid labyrinth is involved, all of the cells seem to be involved at once, although the degree of involvement and of the pathological changes present may vary considerably.

The two types of disease are not recognized as occurring together as one would expect if the one were the sequel of the other as has been suggested, nor are we able to recognize anything that can be accepted as a transition stage from the one to the other. Moreover, it seems difficult to believe that a process that at one stage has laid down considerable bony tissue should at a later stage result in the disappearance of this excessive tissue together with some of the normal supply and that without leaving any residua. We are therefore convinced that the two processes are essentially distinct from the beginning and represent a different response to similar stimuli or different response to different stimuli.

The clinical associations of the two diseases seem to be different also. Dental abscess, deformity of the septum, and intranasal pathology appear to lead to the purulent type of the disease. Acute infections also are followed by the purulent processes. The focal infections leading to arthritis, iritis, retrobulbar optic neu-

FIG. 1. First position.

FIG. 2. Second position.

ritis, etc., appear to be of the purulent type. On the other hand, asthma is clearly associated with the polypoid type.

The exact relationship of these two conditions is still far from clear. Perhaps the majority of surgeons favor the theory that polypoid disease is only a later stage of the purulent type, largely by analogy to the known formation of the isolated polyps about the ostia in the purulent type. Perhaps the distinction is more important to the roentgenologist than to the surgeon, because the roentgenographic evidence is so divergent and because he is attempting to draw a distinction without a difference. It seems to me that the question might well be reopened and the evidence of the roentgenologist might go far towards its solution, as it is the only method short of a mutilating operation that will sharply differentiate between the two.

*Effect on Development.*—A frequent observation and one that appears to me to be of first-rate importance is the relatively small size of the chronically diseased sinus. This feature is always well marked in the juvenile cases, and when it is found in the adult, a history of long-standing disease dating back to childhood may almost invariably be elicited. This is clearly the result of the inhibitory influence of the inflammatory process on the normal growth and development of the pneumatic structures. The result is frequently a high degree of asymmetry.

It is not impossible that juvenile sinusitis is one of the most frequent and important factors in the causation of facial asymmetries, and undoubtedly plays a large part in the failure of development of the pneumatic structures of the head in congenital syphilis. The sinusitis in these cases need not be primarily syphilitic, but the luetic processes in the nose must commonly result in chronic infections of the accessory sinuses of the purulent type.

This also is a subject that is well worth investigating and in which the roentgenologist can be of distinct service to the surgeon.

*Acute Purulent Sinusitis.*—As has been noted in the section on the pathology of acute sinusitis, the only changes that can be anticipated in the roentgenographic picture represent the shadows of the edema and exudates in the sinuses replacing the air usually found there.

Unfortunately, the presence of such exudates in the smaller cavities of the head adds so little to the already considerable density of that portion of the head which the *x*-ray beam must traverse that they leave little record on the plate. This is in agreement with the experimental and clinical experience of others, and is exactly what one would expect from the relatively small cubical capacity of these cells. Experiments show that a similar amount of foreign fluids introduced into the sinuses or applied to the face cast a shadow no greater than that of some of the soft tissue elevations on the face that regularly escape observation.

In exceptional cases the diffuse shadow of what apparently is the exudate of an acute infection is conspicuous and unmistakable. Having seen the opacity of the posterior ethmoids which has followed surgery of the upper nose and having compared them with the density of the same parts before operation and after recovery, I am convinced that these opacities are not the result of bony changes induced by previous infections but are actually due to the recent accumulation of exudates in the tissues and in the free spaces of the sinuses. That pus does produce some shadow is also evidenced by the observed reduction of density of a chronic maxillary empyema after thorough drainage. This is an observation that I have been able to confirm on several occasions.

As to the true explanation of these apparently contradictory findings, your speculations are as good as mine. The significance to the roentgenologist lies in the fact that a negative diagnosis with respect to acute sinusitis is extremely hazardous.

The situation is not improved by the observed fact that acute sinus infections are frequently bilateral, in which case the roentgenologist is deprived of the assistance gained by the observation of symmetrical parts and is forced to judge of the actual and not the relative density of the field under observation. This is especially

true in juveniles where the conditions are particularly unfavorable from the relatively small size of the sinuses and the presence of the germs of unerupted teeth.

Sometimes the upright position and the horizontally directed ray will demonstrate a horizontal fluid level in the antrum. But the shadow is surprisingly faint and the method is not regularly used in this laboratory.

Fortunately for the patient, the surgeon usually does not need the help of the roentgenologist in the diagnosis of the acute conditions, since it is made with comparative certainty on clinical grounds. Not infrequently the *x*-ray is of service in demonstrating some intranasal condition that is apt to favor chronicity and that is likely to escape the surgeon because of the swelling. The roentgenologist will do well to direct his effort to the demonstration of such changes.

*Acute Polypoid Disease.*—Apparently there is a small group of cases in which the process is from the beginning one of polypoid degeneration of the mucous membranes which come for observation early in the disease and before the secondary osteoporosis is manifest. A few of this group have followed obvious dental pathology and the disease has been limited to the antrum. Operation has shown the mucosa greatly thickened with numerous fungus growths bathed in a comparatively small amount of purulent exudate. Such cases have invariably escaped detection by the *x*-ray, and a review of the plates after operation has revealed no recognizable differences from the density or outline of the opposite normal antrum. Perhaps one may assume a nice compensation for the increase in density, due to the thickened mucosa, by an equal loss of density in the bony wall.

Aside from their difficulty of recognition, these cases are interesting in connection with the question of the relationship of the two types of infection, the purulent and the polypoid.

*Acute Purulent Sinusitis.*—The signs of chronic purulent sinus infection are precisely those of an osteoplastic process in the corresponding chambers and in the contiguous portions of the nose and frontal bone. The increase in the density of the shadows appears to be due largely to the increased thickness of the walls of the sinuses. The contents of these chambers play little part in the total density. The diffuse haziness that fills this region is apparently due rather to the thickening of the anterior and posterior walls than to the presence of retained secretions, except that in the larger cavities of the maxillaries the contribution of the latter may be appreciable.

The process is usually unilateral, and the greater density of the entire affected region and the accentuation of the outlines of the individual cells are usually well marked. While solitary infections occur, they are not so common as is usually supposed, and group infections are the rule. The contiguous portions of the nasal wall and in particular the origin, or "root," of the middle turbinate partake of the sclerosis, often with considerable deformity of the nasal fossa. The association of the posterior ethmoid infections with that of the maxillary is so constant that its failure strongly suggests the origin of the maxillary sinusitis in some dental pathology. Actual necrosis of the bone and osteomyelitis occur as an extension of the process in the frontals, but the remainder of the bony structures appear to be too thin to favor such a process elsewhere.

Imperfect development of the chambers involved is of frequent occurrence and is attributed to the inhibitory influence of the infection on the development of the pneumatic structures during adolescence or childhood.

In the antrum the thickening of the walls is most marked along the floor and on the nasal side. Not infrequently the floor of the antrum appears considerably raised above the level of its mate. The diffuse opacity of the entire chamber is due in part to the retained exudates, but mostly to the thickening of the anterior and posterior walls, those portions that are not tangentially projected on the plate. The origin of the inferior turbinate and that of the middle turbinate may show considerable increase in size, thickness and density through an exten-

sion of the inflammatory process by continuity. The posterior ethmoids rarely escape involvement except after infection from the teeth.

In the ethmoidal group, the general opacity is not so striking because of the smaller area of bone and the smaller cubical capacity of the cells involved. The increase in density is usually easily appreciated by comparison with the opposite cells in the comparable positions, while the changes which involve the middle turbinate confirm the diagnosis. In this connection, it should be mentioned that it is necessary to differentiate these changes from the hypertrophies of the turbinates that appear to be compensatory for deviations of the septum. The latter do not, as a rule, show the same increase in thickness and density as do the changes following infection of the ethmoids.

Solitary infections of the ethmoids are uncommon and are most frequently found in the most posterior and external of the ethmoid cells. The changes in the turbinates are either entirely absent or very limited in extent.

Involvement of the anterior ethmoids is less common than the posterior and is rarely seen except as a complication of a frontal sinusitis. The changes are most easily seen about the infundibulum and in the supra-orbital ethmoids. Changes in the turbinates are not a constant feature in this location.

The frontal sinus is peculiar in that its superior and lateral walls are continuous with the diploic structures of the frontal bone and the thickening of the parietal wall is not projected by the tangential ray. There is often, however, a considerable zone of increased density in the frontal bone about the cavity of the cells, and the thickening of the anterior wall is usually sufficient to cast an appreciable shadow. The main reliance for diagnosis must rest on the condition of the infundibulum which invariably shows distinct changes.

Satisfactory plates will show this structure beside the lateral walls of the upper nasal fossa except when they are entirely normal. The infundibular walls are early thickened and the cavity obscured. The irregular members of the anterior ethmoid cell group, which lie in immediate relationship to the infundibulum, regularly show a simultaneous involvement. On the whole, one is rarely left in doubt about the condition of the frontal.

The sphenoid is readily recognized in this technique. Its floor lies on the level of the rostrum sphenoidale and its roof lies slightly below the level of the lamina cribrosa. It is usually roughly quadrilateral in shape, but varies much in extent and contour, often showing wide extensions into the contiguous portions of the maxillary bones. Normally the walls are paper thin and the cavity is strikingly clear. When infected, the increased thickness of its wall is conspicuous and the general density is much increased. In exceptional cases the entire structure is represented by a uniform opacity in which the differentiation between the wall and contents is not possible. The distinction between a sphenoiditis and the occurrence of an intranasal opacity such as a polyp may be extremely difficult.

The septum of the sphenoid is rarely made out because of its obliquity but may occasionally be seen. Unilateral sphenoiditis presumably does occur but has not been recognized in this laboratory, and an early extension to the other cell appears to be the rule.

It will be noted that the approximate location of chronic purulent disease may usually be reached by the observation of the associated involvements. In this judgment the stereoscopic image is of material assistance. This feature, however, is secondary in importance to the assistance the stereoscope affords in the differentiation of the shadows of those portions of the skull that lie posterior but override in the projection of their shadows.

The differential diagnosis must also take into consideration the rare cases of failure of aeration of the accessory sinuses and the persistence of cancellous bone throughout life. This is most frequently seen in the maxillary and presents a very confusing picture. It may usually be recognized by the uniform distribution of its shadows, the smaller size of the maxillary

on the affected side, with resulting asymmetry, and the failure of a definite cortical layer on both sides of the relatively thin wall of the normal antrum.

*Chronic Diffuse Polypoid Sinusitis.*—The roentgenological appearance of polypoid disease of the accessory sinuses is in marked contrast to the description of the purulent type given above. The main features of the picture are produced by the osteoporosis of the bony walls and the exclusion of air by replacement by the overgrowth of the mucous membrane.

The effect on the *x*-ray plate is to destroy to a large degree all the differentiating contrasts and details of the normal sinus cavities. This polypoid process involves not only the cells and their cavities but also completely fills the upper nasal passages with hypertrophied and polypoid mucosa, entirely closing the upper and middle meatus. By contrast the excessive width of the lower nasal fossa through the atrophy of the bony and soft tissue elements of the lower turbinates is accentuated.

The result is a diffuse, hazy plate almost entirely lacking in differentiation and showing only the more massive and more conspicuous structures of the nose. The first impression is that of a technically unsatisfactory set of plates. A study of the detail in the remainder of the plate and a comparison of the relative densities of the sinuses with that of the orbits will convince the student that the trouble is in the former. The atrophy of the inferior turbinates completes the picture.

The process varies considerably in degree in different cases, apparently with the chronicity of the disease. As has already been mentioned, the process is usually bilateral and symmetrical and it is rare indeed that one can say with conviction that any one of the sinuses has escaped involvement. The changes in the maxillaries are often less well marked than in the remainder of the cells, but whether this represents an earlier stage in the development or results from the operation of some protective factor is not clear. The major process is apparently always in the ethmoid regions.

The distinction between this condition and the polyps secondary to the purulent type of the disease and the fibromata and myxofibromata arising from the mucous membranes of the nose must be sharply drawn. The latter are of the nature of neoplasms, although usually considered the result of chronic irritation of some sort. Whether they are true neoplasms or whether they depend on infection should not confuse us as to their essential differences from the condition here described.

Fundamentally, such changes in density as have been described in connection with the purulent and in the polypoid types of disease represent only the structural changes that have occurred in the bones of the skull. These require time for their development and have resulted from infections of considerable chronicity. They do not regularly follow an acute sinusitis or repeated attacks of acute sinusitis which are of short duration. The *x*-ray of the sinus susceptible to recurrent attacks is quite as apt to show no appreciable changes during the free intervals.

These changes are in the nature of scars and may be expected to persist after the process which induced them is concluded. It is therefore entirely conceivable that the sinuses in question in which definite changes have been demonstrated are entirely free from infection at the precise time when they are examined. The diagnosis of "sinusitis" then does not strictly apply. But from what we know of the pathogenesis of the affection one may reason that it is unlikely that the observed changes represent the result of a single acute infective process, and that the persistence of such a suppuration for a time sufficient to induce such changes argues for some impediment to its proper drainage and healing, and for a liability to future recurrences of the infection under similar conditions. It may well be questioned whether a cavity that has once been the seat of a chronic infection is ever again entirely free from infection except through the efforts of the nasal surgeon and by the removal of those factors which contribute to its liability to recurrence.

The sinuses so recognized are therefore constructively, if not actually, inflamed and deserve precisely the same considera-

tion and treatment by the surgeon as those actually the seat of a purulent process.

Unfortunately, the surgeon not infrequently fails to confirm the diagnosis made by the roentgenologist. But one is entitled to accept with reservations the conclusions of the surgeon as to the freedom from inflammatory processes of the indicated cavities, on the grounds that puncture and irrigation have failed to produce any evidence of a purulent secretion. For the process may have been in a quiet interval at the time of puncture and still be a source of future danger through its liability to recurrent infection.

The situation, as I see it, is entirely similar to that of the chronic and latent appendix, and similarly the ultimate judgment as to the potentialities for future trouble and the advisability of operative interference must be viewed with respect to all the facts, including the unsupported evidence of the *x*-ray findings. This judgment must in the last analysis be left to the surgeon. But when the problem is that of a search for a hidden focus of infection, I feel that the roentgenologist is justified in urging surgical procedure on the grounds that his evidence is of as great value as that of the rhinologist, and of similar authority. There have been several instances in my experience where the *x*-ray evidence was the only clear indication of such a focus of infection.

In this connection it may be remarked that a simultaneous involvement of more than one cavity in a purulent process is much more common than the literature would lead one to believe. This is evidently due to the failure of the surgeon to recognize the minor changes in the adjacent cells. This failure may be due to his disinclination to explore farther than he has distinct indications for going, or to obscurity of the field by hemorrhage from the region first attacked. It is also quite conceivable that the adjoining cells are inflamed only intermittently and coincidently with the exacerbations of the process in the sinus primarily involved. Thus, while the *x*-ray evidence persists, the clinical evidence may be lacking at the time of operation. The surgeon is virtually dependent on the finding of pus for a definite opinion, and the sinus in question may be temporarily dry. Whatever the cause, it is obvious that the surgeon is inclined to underestimate rather than overestimate the extent of the process.

More serious differences with the surgeon are apt to arise in the earlier stages of the disease before the osteoplastic changes are sufficiently pronounced to allow of clear roentgenographic demonstration. Nor is it always clear that the time element is alone to blame for the differences in opinion, since the history will occasionally indicate that the infection has persisted for a considerable time. These cases may be very obvious to the surgeon, and he may find it difficult to understand why the *x*-ray does not confirm his diagnosis.

Until we know more about the rate of production of the osteoplastic changes and what are the factors that influence their development, and until we understand more clearly the rôle of exudates and secretions in the production of pathological shadows, we shall be unable to explain every case of disagreement and shall be obliged to acknowledge our limitations with the best grace possible.

In the meantime, it is not necessary in order that the roentgenologist may be of assistance to the surgeon that he agree with him in every case. Such perfect agreement might give a timid surgeon added confidence but could scarcely add to his knowledge and understanding of the case. Identity of observations and opinions means only a reduplication of effort. A certain degree of difference is essential to helpfulness. Difference of opinion may be adjusted, but differences of observation must be explained. If the problem can be approached by both in a spirit of mutual respect for the observations of the other, both must profit by the study of their differences in opinion, with ultimately a closer approximation to the truth on the part of both.

# DIAGNOSIS OF PULMONARY CONDITIONS IN CHILDREN*

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IT is not within the province of this short paper to discuss all the pulmonary conditions in children; so that I shall limit myself to the discussion of some of the problems we are called upon to solve in that particular field. I am frank to confess that I have no solution to offer in most instances, but I wish to call to your attention certain types of lesions which have caused considerable confusion in their diagnosis, hoping that you may aid in the clearing up of some of the obscure points.

We are all perfectly familiar with the markings which we find at the roots of the lungs in the adult; we have come to regard them as normal, if we may use that term in this instance, and we have been interested in determining how early these changes appear in the lungs. With that object in view we have examined a series of children varying in ages from one day to eighteen months. We have observed, as early as the first day, very tiny circular shadows about 2 or 3 mm. in diameter at the ends of the major divisions of the bronchi. It has been suggested that these shadows were minute areas of atelectasis produced in childbirth. If such were the case one would naturally expect the shadows to disappear in a very short time. On the contrary, they remained, became more clearly defined, and as time went on the divisions of the bronchial tree became more and more in evidence, so that at the end of a few months the major divisions of the bronchi could be easily made out. Those children who suffered pulmonary infections showed upon recovery a much heavier outlining of the bronchial shadows. A few developed tuberculosis during the course of the examination and we were able to watch the disease from beginning to end, because all of them died. It is interesting to note that those cases which developed tuberculosis did not show any changes before the sixth month.

We concluded from these observations that one must expect to find certain minor changes in the lungs of all children; the extent of the changes varying under different circumstances.

Granted that we find these changes in all children's lungs, the interesting point to determine is how extensive they may become before we regard them as pathological. The clinicians are in a position somewhat analogous to that of the roentgenologists with regard to the interpretation of the various differences which they find in the physical examinations. They too regard certain minor changes as of no significance, but they also wish to establish what may be termed the normal chest of a child. So the clinicians and roentgenologists have joined forces and a combined examination is being conducted in a number of clinics throughout the country.

A part of the work is being conducted in the clinic with which I am connected, and so far 80 children, above the average in physical condition, have been examined. Their ages varied from three to thirteen years, 17 being six years or less, and they were subjected to the *x*-ray and physical examinations, as well as to the tuberculin test. The examinations were conducted in a routine manner, entirely independently of one another, and the results were afterward correlated. The *x*-ray reports were purely objective, nothing being known of the history of the case; so that an absolutely unbiased report was given.

Of the 80 children examined 32 were considered as normal by the *x*-ray and physical examinations, and 5 had a positive Pirquet reaction with negative *x*-ray and physical examinations. So that out of 80 supposedly healthy children only 32 were regarded as normal by all three tests. It would seem that our tests were too rigid, for while a small number were definitely proven to be diseased, it would be hard to conceive that so large a proportion of the children were abnormal.

* Read at the Twenty-second Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Washington, D.C., Sept. 27–30, 1921.

Two cases were regarded as tuberculous by the physical examination and skin test and two more were so diagnosed by all three tests, so that we had what might be termed an accidental finding of tuberculosis in 5 per cent of the cases.

Eight cases showed signs of old non-tubercular lesions by means of the *x*-ray and physical examinations. Most of these children had had nose and throat infections.

Thirty cases were regarded as pathological by the *x*-ray examination, but nothing abnormal was noted by the physical examination. Three of this group had a positive Pirquet. The *x*-ray reported 14 of this group as tuberculous, 11 had non-tuberculous lesions at the bases, and 8 had enlarged mediastinal glands but with clear lungs.

Summarizing, we see that 48 out of 80 showed changes in their lungs which were regarded as pathological by the *x*-ray, whereas pathology was demonstrated by the phycsal examinations in 15 cases only. It is no doubt true that some of the lesions were so situated that they could not be detected by the physical examination, but that number must have been very small.

It will be seen that the results of the *x*-ray examinations were much too critical in spite of the fact that a conservative attitude was adopted in the interpretation of the findings. Therefore, it is impossible for us to adopt certain criteria and say that any variations from them mean that the child has a pathological condition which is producing symptoms. A solution of this problem is very difficult to obtain because there are so many factors causing changes in the lung picture which do not have any immediate bearing upon the case. As was shown in our work with the very young children, pulmonary infections leave their marks upon the lungs after they have healed. Environment, too, seems to play a very important rôle. Children raised under poor conditions show more extensive lung markings than those whose surroundings are more ideal. Consequently, there should be a close collaboration between the roentgenologist and the clinician and a diagnosis should not be given, much less any therapy suggested, upon the *x*-ray findings alone.

### ACUTE INFECTIONS OF THE LUNGS

Two of the acute pulmonary infections we shall dismiss with just a passing word. The first, acute bronchitis, does not cause any changes which are demonstrable by means of the *x*-ray examination. The second, lobar pneumonia, is usually very easy to demonstrate. We may remark in passing that pneumonic consolidations are detected much earlier by the *x*-ray than by the physical signs because they so frequently begin at the periphery of the lung and extend in toward the mediastinum, and the changes in the physical signs cannot be demonstrated until the consolidation has reached one of the larger bronchi.

*Bronchopneumonia.*—While the diagnosis of lobar pneumonia is comparatively easy, it is often very difficult in bronchopneumonia, and while the former usually clears up promptly without leaving any markings in the lungs, the latter may frequently cause changes which persist for a long time. This is true because lobar pneumonia involves chiefly the parenchyma of the lungs, whereas bronchopneumonia attacks the bronchi and interstitial structures of the lungs.

Bronchopneumonia in its acute stage is characterized by areas of consolidation of varying size with rather indefinite outlines which may occur anywhere in one or both lungs, though they are more frequently found at the bases. At this stage it is to be differentiated from tuberculous consolidations and metastatic sarcomata. It is sometimes impossible to differentiate bronchopneumonia from the consolidations of tuberculosis, though the latter more frequently spring from the mediastinum and are usually associated with enlarged mediastinal glands. The outlines of the sarcomata of the lung are more clearly defined and their distribution is more widespread and regular than bronchopneumonia.

If the disease progresses to the chronic stage we have great difficulty in differentiating it from tuberculosis. The *x*-ray examination at this stage shows that most of the areas of consolidation have cleared up, but there is a very extensive fibroid infiltration which outlines the bronchial tree, with thickened and dilated bronchi and groups of enlarged, very dense glands

scattered throughout the lungs. In more severe cases bronchiectasis develops and cavitations sometimes occur. Tuberculosis frequently gives just such a picture.

The pathology of the disease seems to offer a logical explanation of our findings. Bronchopneumonia is usually a secondary disease, and, as has been stated, causes marked, changes in the bronchi. This is particularly true if it follows influenza or pertussis. Hemorrhages occur in the walls of the bronchi followed by a breaking down of the tissues so that an actual ulcer develops. If the bronchus becomes plugged up and its wall weakened below the obstruction, bronchiectasis occurs, and if the infection extends through the wall of the bronchus into the lung tissue an abscess is formed which results in a cavity. Since the influenza epidemic, bronchiectasis and lung abscesses occur more frequently than formerly. When the process of repair starts, fibrous tissue appears, scar formation takes place, and the adjacent glands react to the infection.

We know that tuberculosis causes a fibrosis in the lungs with an enlargement of the glands, and we have just seen that bronchopneumonia also causes a fibrosis, so that we can readily understand why they give such identical results upon *x*-ray examinations. We may judge of the difficulties in differentiating bronchopneumonia in this stage from tuberculosis, when the pathologists state that such a differentiation frequently cannot be made by them until the microscopical sections are examined.

*Tuberculosis.*—There is a period in the child's life which extends from about the sixth month to the sixth year, in which tuberculosis is very active. Then comes a period of quiescence, which lasts until the age of puberty, when the disease again becomes very active. Of course, a good many cases of tuberculosis are seen in the quiescent period, but they are not usually so active as they are either earlier or later in life.

The vast majority of tuberculous infections in adults are found in the upper portions of the lungs, but such is not the case in children, especially in those infections which occur very early in life. At that time one may expect to find the primary lesion anywhere in the lung, and a tuberculous consolidation at the base is not at all uncommon. As we believe that most of the tuberculosis that occurs in adults is the result of childhood infection, one might inquire why they do not present basal lesions. The reason is that practically all the children who have a very early infection die.

Tuberculosis, occurring very early in life, shows all the signs of activity, that is, soft snowflake or miliary infiltration with perhaps areas of caseous consolidation and cavitation. Pleural reactions are not infrequent.

As the child gets older and we find the disease in its less active form, we commence to see the localized, fan-shaped areas of infiltration that are associated with tuberculosis in adults. Unless the infiltration is localized, the diagnosis is extremely difficult, but we have one sign which we regard as very helpful; that is, the enlargement of the mediastinal glands. No other infection of the child's lung seems to cause such an enlargement of the mediastinal glands as tuberculosis, and we have come to regard it as almost pathognomonic of the disease, especially in young children. Gohn's theory of the transmission of tuberculosis by the lymphatics of the lung would seem to account for this enlargement of the mediastinal glands.

Children often have tuberculous infections which later become arrested or inactive, yet definite anatomical changes are produced which are seen on *x*-ray examination. Just because we find evidences of what we regard as a tuberculous infection we are not able to conclude that the child is suffering from tuberculosis. While a tuberculous infection is always a potential source of danger and such a child should be carefully watched, it by no means follows that its whole scheme of life should be changed upon the bare evidence of the *x*-ray findings. Bearing in mind the experiences with the healthy children which I have previously quoted, we can see that there is room for a large source of error.

*Thymus.*—The diagnosis and treatment of persistent thymus has caused considerable discussion. For a number of years we reported all cases as persistent thymus that

had a very definite enlargement of the mediastinal shadow. Except in a very few cases the pathologists were unable to find any evidence of a thymus but did find many cases of enlarged tuberculous glands. The clinicians, too, did not give us much encouragement because they could not find any clinical evidence of persistent thymus. In the light of such evidence we were compelled to render a diagnosis of enlarged tuberculous mediastinal glands in cases of the type under discussion. However, we have seen from time to time a number of cases of stridor having an enlargement of the mediastinal shadow. We have radiated these cases and have observed the results.

One group of these cases failed to respond to radiation in any way. Their stridor did not improve and there was no diminution in the size of the mediastinal shadow. If any of this group had a thymus, the amount of radiation was not sufficient or the thymus was peculiarly resistent to radiation.

Another group showed marked improvement in their stridor but the mediastinal shadow remained the same. Some of this group may have had a thymus, but if they did one would expect a diminution in the size of the mediastinal shadow with improvement in their stridor. We must remember that a large number of children with stridor improve without any treatment whatsoever.

Finally, a third group showed improvement in their stridor and a complete disappearance of the mediastinal shadow. It is a well-known fact that tuberculous glands respond rather readily to radiation, which may account for the improvement in some of these cases, but there were a few, too young to have tuberculous glands, who must have had a thymus. We therefore concluded that the majority of these cases had tuberculous glands, while a very small number had a persistent thymus.

*Pulmonary Findings in Rickets.*—The pulmonary changes associated with rickets usually occur within the first three years of the child's life, when the disease is most active. They are produced by a softening and weakening of the ribs so that the negative pressure exerted during inspiration with the elasticity of the lungs and pull of the diaphragm cause a partial collapse of the thoracic walls. Moreover, the disease does not attack the cartilages as it does the ribs, so that the latter yield to the pressure and are displaced inward. This may take place to such a degree that instead of the ribs articulating with the cartilages on the same plane they are displaced inward and are sometimes actually overlapped by the cartilages. A distinct knuckle is formed on the internal surface of the thoracic wall at the costochondral junction, and when the process of repair commences a large amount of new bone is deposited in the ends of the ribs, which greatly enlarges the knuckles.

The partial collapse of the thoracic walls which produces great pressure on the lungs and the knuckles at the costochondral junction, causes marked localized pressure. The pressure of the knuckles is evidenced at autopsy by a distinct groove which is seen on the anterior surface of the lungs, running from the top to the bottom and lying immediately under the costochondral articulations. An area of atelectasis of the lung is seen immediately posterior to the groove. Anterior to the groove the lung may be emphysematous, and areas of atelectasis and lobular pneumonia may be scattered throughout the lungs, which are somewhat edematous.

The *x*-ray examination of these cases shows a marked deformity and increased porosity of the ribs with a marked enlargement of their anterior ends. The lungs show longitudinal shadows of irregular outlines, 1 or 2 cm. in width, extending from above downward on both sides of the heart. They extend from the clavicle to the base and are separated from the heart by a narrow, clear area. Numerous small areas of consolidation may be seen scattered throughout both lungs. The whole lung field frequently presents a hazy appearance. The small areas of consolidation already noticed may be so diffuse as to give the appearance of a tuberculous infection, and the longitudinal areas may be so large as almost completely to obscure the lung fields.

The difficulties of the diagnosis of any concurrent lung infection in a child who has rickets are obvious.

# UNSUSPECTED DERMOID CYST DIAGNOSED BY ROENTGEN EXAMINATION

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MISS D. G. Aged seventeen years; stenographer.

*History.* Chief complaint, sharp shooting pain in right inguinal region. Vaginal discharge (leucorrhea) and burning sensation on micturition.

*Present Illness.* Dates back two weeks when patient had sudden attack of severe sharp shooting pain on the right side of the abdomen, markedly increased upon retiring, and continuous.

*Menstrual History.* Menstruation began at the age of thirteen. Menstruated regularly until six months ago when she missed this period but has menstruated regularly since then to date. Each period lasted from six to eight days.

*Medical History.* Three years ago had psoas abscess. Two years ago had influenza and pleurisy.

The patient was referred for roentgen examination of the urinary tract with a provisional diagnosis of ureteral stone.

*Roentgen Report.* No evidence of calculus anywhere in the urinary tract. Kidneys are normal in size, shape and position. Just to the left of the lower border of the sacrum there are a number of undeveloped teeth imbedded in a matrix of bone. Diagnosis: Dermoid cyst.

Operation was performed by Dr. J. C. Hirst, who found a large left ovarian cyst (dermoid) which was removed. The right ovary also showed some cystic degeneration and the diseased area was removed. The appendix was found to be the seat of a chronic inflammation, which in all likelihood was the cause of her present illness, and which was removed.

FIG. 1. Showing dermoid cyst revealed by roentgen rays.

# THE LUMBAR SPINE AND SACROILIAC JOINTS*

BY MYRON B. PALMER, M.D.

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THE roentgen-ray examination of the lumbar spine and sacroiliac joints still offers many possibilities for future study. Of the patients who come to the orthopedic surgeon for consultation, a fairly large proportion present symptoms referable to the lower back.

It is not my intention to go into a discussion from the orthopedist's standpoint, but rather to present for your consideration the interpretation of anatomical variations or developmental conditions noted in the lumbar spine of patients with lower back pain.

There is very little to be found in the textbooks in regard to anatomical variations of the lumbar spine and their relation to lower back pain.

In the last few years there have appeared in the various journals, especially the orthopedic journals, articles and discussions on the variations noted in the lumbar spine and sacrum as a causative factor in back pain. Several members of this Society have at various times discussed the lumbar spine, but more particularly in regard to fractures.

Professor Dwight's work has shown what a variety of anatomical anomalies may exist in the bony structure, particularly in the lumbar spine. He once said that anomalies of the fifth lumbar vertebra are so common that we hardly know what the normal should be.

Boehn has advanced several theories as to variations in the fifth lumbar as a possible cause of certain types of scoliosis. He also emphasized the possibility that asymmetrical sacralization might cause a lateral tilting of the top of the sacralizing vertebrae and thereby cause scoliosis.

Adams,[1] in a very able article on scoliosis, says that though Boehn's theories are interesting, in the work done at the Massachusetts General Hospital on the backs of scoliotics, asymmetrical sacralization was frequently found in normal cases, or cases presenting no symptoms, and that at the Children's Hospital in the cases that did have scoliosis and asymmetrical sacralization, no tilting was noted. He did, however, consider the possibility of congenital defects of the articulating processes as being a more logical cause of scoliosis.

The work of Dodd and Holmes at the Massachusetts General Hospital shows how well they had studied variations in the last lumbar joints and the sacrum.

Davis[2] says that while anatomy, per se, is an exact science, our knowledge of the anatomical lesions causing backache is so limited that any attempted explanation of cause and effect must be largely theoretical even though we do our best to make them rational. He emphasizes the fact that fracture of the lumbar vertebrae is rare and places much emphasis on the injury to nerves and ligamentous structures as the cause of pain.

Other writers lay great stress on injury to muscles rather than to ligaments or bony anomalies.

Goldthwait[3] calls attention to dorsal lumbar pain which may be confused with lower back pain, or pain from kidney pathology, and shows many illustrations of variations in the articular processes and the transverse processes which should be given consideration in the study of each case.

O'Reilly[4] has analyzed quite a series of general clinical cases, that is, cases presenting no back symptoms, and has shown a large number of anatomical variations in the lumbar spine, more especially the transverse processes. He classifies the sacrum as to three types, according to size and shape; taking into consideration the various types of anatomical variations, no general type could be called normal.

It has been the writer's good fortune to be associated with orthopedic surgeons and to know case histories; to be able to

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sit down, as it were, and talk over the various conditions found in the lower back. In this way one can obtain a much better understanding of this perplexing lower-back problem. Although all types of variations are studied, more attention has been given to the articulating processes.

Goldthwait has described two types of articulations: the transverse or flat type, and the vertical or crescentic type. We have designated the vertical or crescentic as the true lumbar type and the flat as the sacral or dorsal type (Figs. 1, 2, 4). Nearly all cases presenting symptoms referable to the lower lumbar vertebrae have a mixed type of joints. There may exist lumbar types of the first, second and third joints, while the fourth may be sacral, or lumbar and sacral; likewise the fifth may be sacral or the mixed type. Rarely is it possible to see two lumbar joints at the lumbosacral articulation (Fig. 3). The true lumbar is well shown on the film as a vertical line between the processes, whereas the sacral or dorsal type faces you and gives an indistinct joint outline with irregular borders which may at times resemble bony overgrowth (Figs. 1 and 4). There are noted also the position and shape of the transverse processes: attempts at sacralization or lumbarization of the upper sacral segment; whether there is a large fan-shaped transverse process; if it fuses with the sacrum or has a distinct articulation which overrides the superior wing of the sacrum. Stereoscopic films will show with considerable accuracy whether the fifth transverse process impinges on the upper sacral wing or on the iliac crest. Rarely is the fifth transverse process seen to override the crest of the ilium, though the single roentgenogram seems to show that it does.

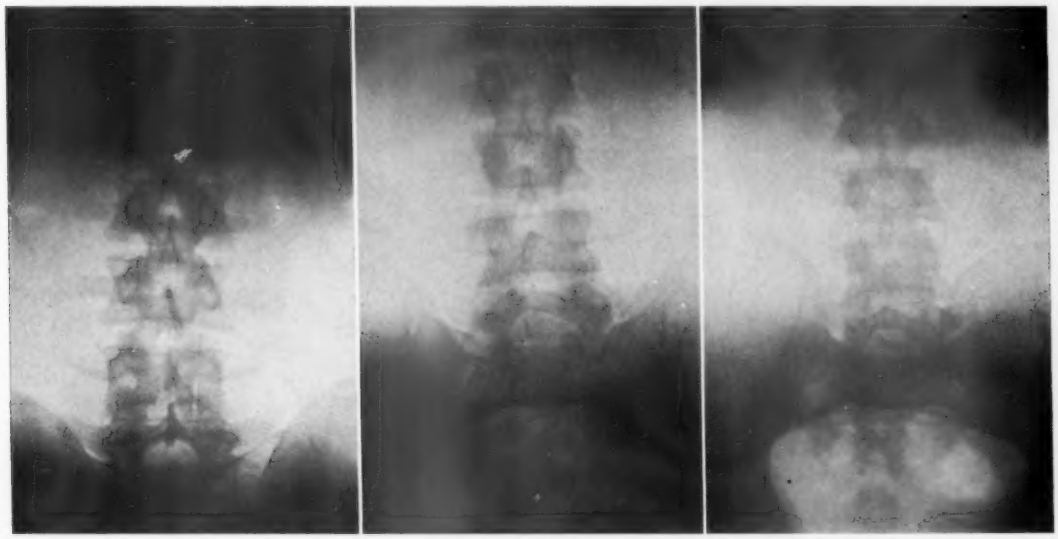

FIG. 1. FIG. 2. FIG. 3.

FIG. 1. True lumbar type of joints with the exception of the articulations between the third and fourth, and the fourth and fifth, which are the mixed type. The lumbosacral articulations are of the true sacral type. FIG. 2. Lumbar type articulations persist throughout lumbar vertebrae with exception of the lumbosacral joint, the left being the lumbar and the right the sacral type. FIG. 3. True lumbar types in all articulations.

Certain cases show a well marked projection or tubercle on the ilium for the attachment of the lumboiliac ligament.

The general size and shape of the sacrum are considered, and the height of the fifth lumbar above the line of the iliac crests; all these conditions are taken into consideration in cases having lower back injuries with pain.

My belief is that the roentgenologist's duty ends in mentioning only what he sees on his films, but that close association with the orthopedist will greatly aid him in interpretation and general diagnosis.

What shall be the evidence necessary for the interpretation of an arthritis? Acute infectious arthritis of the lower lumbar and sacroiliac joints is not common in the general class of cases with acute back symptoms. When seen in the sacroiliac joints it gives a distinct picture, unless it be in the very early stage. In the lumbar articulation the interpretation is much more difficult. In hypertrophic or osteoarthritis more than one joint is involved and the interpretation is more easily made from characteristic lipping or bone production. Is it not possible for error to be made in interpretation of an osteoarthritis of the lumbar joints or the lumbosacral joints? Such errors have been seen repeatedly.

FIG. 4.

FIG. 5.

FIG. 6.

FIG. 4. Large flat sacral type of articulations between third and fourth, fourth and fifth and the fifth and sacrum. FIG. 5. Prevailing types of articulations are sacral, exception being the right articulation between the fourth and fifth. FIG. 6. The three legged stool type. Elevation of right lamina and articulating processes. Noted in certain types of scoliosis.

To the orthopedic surgeon arthritic joints give symptoms of a different character than those of lower back strain. Although certain cases may be confusing, a careful study of the case will easily differentiate the two types.

The overgrowth of bone about the flat or sacral joints has the appearance of production from arthritic change, but careful observation of roentgenograms of symptomless backs will demonstrate that these flat articulations are common.

What evidences should be required to interpret injury? Extreme violence may produce fracture of one or more of the bodies of the lumbar vertebrae, though compression fracture is less common than in the dorsal bodies. Fracture of the transverse process is somewhat common, occasionally accompanied by fracture of the spinous processes. Fracture of the articulating process and the lamina are very uncommon or may be difficult of recognition. Fracture of the lumbosacral articulation is apt to be accompanied by a slipping forward, or what might be called a unilateral dislocation, or when both processes rupture, a bilateral dislocation. In such injuries lateral views are valuable, while stereoscopic anteroposterior views should show a complete distortion of these flat sacral articulations. There may exist with a unilateral slipping forward of the process, a similar picture to that seen in certain types of congenital scoliosis. These injured cases eventually show degrees of lumbar curvature and rotation which are difficult to differentiate from the deformed congenital type of spine (Fig. 6). Distort one articulating process either by elevating it or carrying it forward, and rotation will take place with the change in the spinal balance. How are we to differentiate these types?

In the middle-age period it is difficult definitely to diagnose fracture of the articulating processes which show what seem to be anatomical variations accompanied by sacralization of the upper sacral segment or an old spina bifida. Our problem becomes one of extreme difficulty in passing judgment on these industrial cases. What influence will anatomical variations have in the interpretation as regards lower back pain? These variations are seen so frequently in the symptomless back, that in our present knowledge of these conditions we cannot justly say that the cause is due to these developmental defects. However, a general conclusion should be drawn from the history of the case and symptoms; occupation and its relation to posture; pain, its location and if referred; straight leg raising and the degree; conditions which may change the weight bearing, bringing into play a joint which has always been improperly built or weak for the work which it is required to do. Such a joint in time of stress fails to perform its proper function. This may be especially true of the lumbosacral joints. Let us suppose one lumbosacral joint is of the true lumbar type and the other of the sacral type, very flat. The lumbar joint will be free for forward and backward bending, while its fellow, the flat one, tries to operate at right angles. Undue stress is therefore placed on one or the other. Inflammatory change may take place with the accompanying nerve and muscle pain.

The cervical and lumbar joints have the greatest range of motion, especially forward and backward bending, while the dorsal has less motion and the motion becomes quite limited in the lumbosacral articulations.

The plane of the fifth lumbar on the sacrum has a tendency to slide forward, being placed at about 40° from the horizontal. It is held by the bony support of the superior articulating facets and the various ligaments and muscles. The processes vary as to the position at which they are placed. They incline forward and inward and the pressure is downward and forward.

The structures which prevent this slipping forward are the ligaments; the fibers of the intervertebral disc, which allow, of course, a certain degree of motion; the anterior and posterior common ligaments; the iliolumbar, the lumbosacral, and the ligamenta subflava of the spinous processes. Any or all of the ligaments may slowly stretch, as is possible for a ligament about other joints. Certainly the joint is called upon to do quite unusual duty.

Elevate one process or place it at a different plane anteriorly, and what do you do? The entire spinal balance is altered, even though the change in the joint be so slight as to be hardly perceptible. This may be theorizing to a certain extent, but it is the belief of many, and, so far as it has not been disproved, it seems rational to accept this theory as a cause, at least in those cases showing varying degrees of rotation without marked deformity either of the transverse processes or the sacrum.

## CONCLUSIONS

Anatomical variations or developmental defects are seen in a great number of patients presenting symptoms of lower back pain following injury. These variations are also seen in cases that have no back symptoms.

It is reasonable to consider that anatomical variations in the lower lumbar joints may under stress and varying influences be a factor in the causation of lower back pain.

Arthritis should show a definite picture and should not be confused with anatomical variation of the processes.

A more definite conclusion can be arrived at with the close association of roentgenologist and orthopedist.

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# THE TREATMENT OF CARCINOMA OF THE THYROID BY THE ROENTGEN RAYS AND RADIUM*

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A SEARCH through the "Quarterly Cumulative Index to Current Literature" during the past five years, and a hasty review of other medical indices, have failed to show a record of the treatment of carcinoma of the thyroid listed under this heading. It is likely that many cases have been treated and are probably recorded in literature under such general terms as the "Treatment of Carcinoma," but it has been impossible for me to review all these general papers. We shall obtain a more definite idea of the value of this treatment, therefore, if those who have had the experience will describe their results in the discussion of this paper, or place them on record by correspondence with the Journal after the paper is published. As will be shown by subsequent case reports, my experiences have extended over a period of eleven years, and the results have been generally most gratifying, for in nearly all instances the treatment was used in an otherwise hopeless group, and yet the results have been in some cases brilliant. I want to place on record ten cases. In addition to these there were two other patients treated too short a time to make their records of any value, having only started the treatment and the patients having failed to return.

CASE I. M. G., female, aged thirty-six, referred by Dr. John B. Deaver, June 14, 1910. She had been operated upon by Dr. Deaver three times; first, July, 1908, for carcinoma of the thyroid, and March, 1909, and May, 1910, for recurrences, and she was referred to me on account of a recurrence consisting of an indurated mass in the region of the wound immediately above the clavicle on the right side, and another indurated movable tumor mass, 1 inch in diameter, located below the mastoid on the right side. She was treated by fractional doses through 4 mm. of filter, the applications being made twice a week, so that each side of the neck was treated once a week and the dosage amounted approximately to half an erythema dose. Four different gas tubes were used at each visit in order to give this half erythema dose, because the gas tubes did not hold their vacuum sufficiently long to continue the penetration during the whole treatment. Under treatment the patient apparently regained health for about a year, and there was no local recurrence at any time; but about eighteen months after beginning treatment she developed signs of metastasis in the neck, and died July 5, 1912, with complete paralysis of the body below the cervical vertebrae, or approximately two years and one month after beginning treatment.

*Remarks.*—In a sense the result in this case was a failure; but the malignant disease which was palpable had disappeared and the patient undoubtedly had her life prolonged. She was given a year of reasonable comfort, and finally died of metastatic disease in the spine which had probably been growing slowly over a long period. It must be borne in mind that treatment was started in this case after the third recurrence had developed. This is an argument in favor of active treatment of the primary growth, or of very prompt and thorough treatment to be given immediately after the operation.

CASE II. J. P. P., female, aged fifty-one, was referred November 16, 1911, by Drs. J. M. Anders and F. S. Parke. She had noticed a swelling of the neck and tightening of the collar during a year, but more rapid swelling of the right side of the neck during four months. This was associated with shortness of breath, palpitation and dyspnea, and she broke out into cold sweats. Examination showed a tumor involving the right lobe of the thyroid about 3 inches in diameter, which by *x*-ray examination was found to extend down into the upper mediastinum. It was indurated

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and fixed to the surrounding tissues. Dr. Anders believed it to be a carcinoma and that her condition did not warrant an operation. Dr. L. Webster Fox made an examination of the eyes and reported that he did not find the ocular symptoms of exophthalmic goiter. Her pulse was 160. *X*-ray treatment was undertaken with little hope of success. She was treated three times a week for one month by fractional doses, each dose amounting practically to ⅓ of an erythema dose. Twenty ma. minutes were given at a distance of 12 inches, filtered through 4 mm. of aluminum, and a 7 inch parallel spark gap was used. The treatments were given alternating left and right. Within three weeks her pulse was reduced from 160 to 120. Treatment was discontinued at the end of a month, but her improvement was progressive, and within three months she had regained her health. A letter of inquiry in 1918 (seven years after the treatment), brought the following report from the daughter: "Mother is in better health than she has been for the last twelve years. She has had no other treatment than the *x*-ray treatment given by you." Presumably she is still living and well, though the address has been lost.

*Remarks.*—The diagnosis in this case is, of course, open to question. There was no operation and there were no microscopical studies, but the clinical diagnosis seemed to be that of carcinoma and at the beginning of treatment none of us had much hope. She was, however, inoperable, and the probabilities are that if the treatment had not been given she would not be living. We have, therefore, almost certainly prolonged her life at least seven years according to the last report, and probably many more.

Case III. L. S., female, aged forty-six, referred by Drs. Geo. P. Katzenstein and John B. Deaver, February 10, 1913. She had had a goiter for twenty years. She was operated upon by Dr. John B. Deaver two weeks previous to the time she was referred to me, at which time he encountered much hemorrhage and degeneration of the tumor, and on section it was found to be carcinomatous. He stated to me that it was impossible for him to remove all of the tumor tissue, and that he knew he had left part of the carcinoma behind. The wound had not entirely healed at the time of beginning treatment. Her pulse was still 130. She was nervous, excitable, and had symptoms of hyperthyroidism. She was given ⅛ of an erythema dose at each visit, and she was treated nearly every day, making use of a coil and treating her successively on the right side, the median section and the left side, including treatment also in the supraclavicular regions and the upper sternal region. This treatment was continued almost daily for three months, then three times a week for three months, and treatment was discontinued completely December 2, 1913, ten months after beginning treatment. She has been observed from time to time since then and was last seen September 19, 1921. She is in perfect health, pulse normal, neck normal, excepting very slight and scarcely visible telangiectasis.

*Remarks.*—This patient is alive and well, eight years after beginning treatment of the remnants of carcinoma which were known to be left in place by one of our most competent surgeons, who stated at the time that he knew he had left carcinoma in the neck. The treatments were given in fractional doses with moderate filtration and spark gap approximately 6 or 7 inches in length. The results are probably equal to any that could be produced to-day by our more modern and more violent treatment.

Case IV. P. K., female, aged thirty-one, was referred for postoperative treatment by Dr. Charles H. Frazier, October 12, 1917. She had been operated upon June 13, 1917, by Dr. George Ross, for a branchial cyst involving the right side of the neck. September 25, 1917, Dr. Charles Frazier operated for goiter of the right lobe which, when examined by the pathologist, was found to be adenosarcoma. A section was then made of what was supposed to be a branchial cyst at the time of its removal in June, and this too was found by Dr. Allen J. Smith to be malignant. *X*-ray examination of the chest showed an abnormal amount of thickening or dense material about the root of the right lung and extending up along the right mediastinum. The right side of the diaphragm was retracted

upwards. This was believed to be due to thickened pleura, but on account of the diagnosis of malignancy in the neck, treatment was advised to be applied to the mediastinum as well as to the tissues of the neck. The neck was divided into six portals of entry, and in addition to this the patient was treated through each side of the chest anteriorly, through the axilla, and posteriorly, making twelve portals of entry in all. She was given one full dose of rays through each of these portals of entry in the first series, each dose consisting of eight minutes' exposure at a focal skin distance of 8 inches, with a 9 inch parallel spark gap, 5 ma., and 6 mm. of aluminum filter. During the second series fourteen portals of entry were used; during the third series ten portals of entry; the fourth series, ten portals of entry, and the fifth series, eight portals of entry. At this time, December 15, 1917, the patient seemed to be free from any evidence of disease, and active treatment was discontinued. This was approximately two months after beginning treatment. March 20, 1918, she returned complaining of pains in the neck; and on account of the experiences of the first case, which developed metastasis in the neck, an *x*-ray examination was made and there was suspicion of disease in the lamina of the second cervical vertebra. Therefore, a sixth series of treatments was given through fourteen portals of entry. A seventh series was given May, 1918, and she has had no treatment since. She was re-examined September 19, 1921, and is in perfect health.

*Remarks.*—This patient had two operations on the neck for malignant disease. One of these was supposed to be for a branchial cyst, the second for carcinoma of the thyroid. The patient is well and free from disease more than three years after discontinuing treatment, approximately four years since her last operation.

Case V. G. S., male, aged sixty-two, was referred to me by Dr. Geo. P. Muller, November 17, 1917, after an operation three weeks previously for carcinoma of the left lobe of the thyroid. Dr. Muller reported that he was unable to get all of this carcinoma out. It was found to be infiltrated about the great vessels so extensively that it was impossible to remove all of it. Microscopical examination proved it to be malignant. At the time that he was sent for *x*-ray treatment he had some lymphedema and the tissues were indurated about the line of incision. The patient received his first series November, 1917, consisting of treatment through seventeen portals of entry. A second series was given through sixteen portals of entry during the succeeding month, and a third series through eighteen portals of entry during the month of January, 1918; a fourth series consisting of twenty doses during March, 1918; a fifth series through eighteen portals of entry during April, 1918; a sixth series during July, 1918, and a seventh series, consisting of fifteen doses, during October, 1918. At this time he looked perfectly well though the anterior portion of the larynx was still rather firm, but it did not feel like malignant disease. His voice was still rather hoarse, but no more so than at the beginning of treatment, and probably less. *X*-ray examination still showed some thickening in the upper mediastinum. The patient discontinued treatment and left my care at this stage, but I learn that he died November, 1919, with paralysis of the lower extremities.

*Remarks.*—This patient had two operations in the region of the thyroid for carcinoma; malignant disease found; left in place at the time of the second operation; yet as a result of treatment the disease in the neck was controlled; the patient lived comfortably for about a year, and died two years later with metastasis in the spinal column.

Case VI. J. W. A., female, aged sixty-one, was referred for treatment by Dr. John B. Deaver, June 27, 1917. Within two and a half years she had been operated upon four times for carcinoma of the thyroid and recurrences. The last operation was June, 1917. The patient was given nine courses of treatment within a period of six months. In each series treatments were given through fifteen to twenty portals of entry. The patient had difficulty in respiration at the very beginning. She suffered from hoarseness which gradually developed into aphonia. She had distinct evidence of mediastinal disease, as shown by the roentgen rays, at the beginning of

treatment. There were periods of improvement, and by *x*-ray examination the mediastinal disease seemed to diminish, but as a whole the progress was downward, and the patient died December 13, 1918, almost six months after she was originally referred for treatment.

*Remarks.*—This patient was referred for treatment late in the disease, after having had four operations; first for the primary disease and three times for recurrences. The disease had invaded the mediastinum at the time of beginning treatment, and progressed without appreciable improvement or control until death.

Case VII. C. P., male, aged sixty, was referred by Dr. H. L. Foss of Danville, Pa., and Dr. F. G. Runyeon of Reading, Pa., January 31, 1919, on account of carcinoma of the thyroid. During several years the patient had suffered from goiter, but during the preceding eight months the growth had interfered with his breathing. Dr. Foss operated January 15, 1919, but was unable to remove any part of the tumor excepting a section for microscopical examination which showed it to be malignant. He reports as follows: "Exposed the gland which grossly was carcinomatous and removed two sections for diagnosis. One was sent to the Pathological Laboratory at the Mayo Clinic, the other to our consulting pathologist, Dr. Kolmer. From both places I got a positive report of carcinoma."

The entire thyroid was involved. The entire neck was thickened. The tumor tissue involved the surrounding tissue and seemed to mat everything together. I made an *x*-ray examination of the chest and found that this growth extended down the neck into the upper mediastinum. Briefly, he was given ten series of treatments within sixteen months, when he seemed to be well. He has had no treatment since April, 1920. Each series involved treatment through eighteen to twenty portals of entry and treatment was given not only through the neck but into the mediastinum from all parts of the chest. We believe that he is well. He is attending to business every day and feels well excepting that occasionally he expectorates blood. On account of this expectoration of blood I sent him to Dr. Chevalier Jackson, April 21, 1921, who reports as follows: "The motility of the larynx is perfect. The laryngeal mucosa is very much engorged and the vessels seem relaxed, but there is no infiltration, no ulceration and nothing to indicate malignancy. The source of blood is most likely from the rupture of capillaries in the trachea, but this, of course, is an inference."

*Remarks.*—This patient is apparently well, nearly three years after a definite microscopical diagnosis of carcinoma of the thyroid without operation and with nothing removed excepting the sections. His general health is perfect. He is feeling comfortable. The occasional expectoration of blood is probably due to the dilated capillaries, and the dilated capillaries are probably similar to the telangiectasis which develops in tissue that has been much treated on the surface of the body. He is kept under continuous observation; but we can be quite sure that he has been given at least several years' prolongation of life, with the hope of a real cure.

Case VIII. P. W. B., female, aged thirty-two, was referred by Drs. John B. Deaver and Wm. Jennings, June 14, 1919. Three weeks previously Dr. Deaver had operated on her for carcinoma of the thyroid, which had been noticed only three months previously. At the time of coming for treatment, *x*-ray examination showed no evidence of mediastinal or pulmonary disease. The patient had some general induration about the tissues of the neck which was believed by us to be inflammatory and not a recurrence. She was given four series of treatments involving twelve doses, each given through twelve portals of entry, each portal of entry receiving a full erythema dose filtered through 6 mm. of aluminum. On November 6, 1919, on account of soreness in the neck of which she complained, she was given a fifth series. She has had no treatment since. She was examined last by me personally, May 7, 1920, approximately a year after her original operation, when she seemed to be entirely well. Letters received from the patient and from her doctor state that she is still well, September 9, 1921.

*Remarks.*—More than two years have

passed since this patient had an operation for carcinoma of the thyroid. She has been given, in all, five courses of treatment and has apparently recovered.

CASE IX. T. H. B., male, aged forty-five, was referred by Drs. W. R. Paulis and H. S. Foss of Danville, Pa. December 10, 1919, he was operated upon for carcinoma of the thyroid, but only sufficient tissue was removed for microscopical examination, because Dr. Foss found the disease to be malignant and totally inoperable. Microscopical examination showed it to be carcinoma. He had had a goiter approximately ten years, but it had been growing during six years and quite rapidly during the four months before operation. When lifting he suffered very severe pain. The neck measured 17½ inches in circumference, but all the tissues were matted together into a nodular tumor mass. Roentgenogram showed a tumor extending 5 inches downward into the mediastinum and 4 inches in front of the spinal column, and upward to the top of the thyroid cartilage. He showed improvement both locally and symptomatically after the first course of treatment, consisting of 22 doses given through twenty-two different portals of entry. There were twelve portals of entry through the neck, and the remainder of the treatment was given through the chest directed towards the mediastinum. He was given four such treatments within five months. The disease then seemed to be at a standstill, and in June, 1920, sixteen radium needles containing 10 mg. each were inserted into the tumor tissue and left in place fourteen and a half hours. This was repeated again August 19, 1920, two months later. He received a seventh series of *x*-ray treatments, consisting of 6 doses, in October, 1920, and again an eighth series, consisting of 4 doses, in December, 1920; a ninth series, consisting of 2 doses, in February, 1921, and a tenth series, consisting of 2 doses, in April, 1921. He has had no treatment since. He is working every day on a farm and seems to be in excellent condition.

*Remarks.*—One year and nine months have passed since this patient had an exploratory operation at which only sections could be removed for microscopical study, and at which time he would otherwise have been left to pass the usual course of malignant disease. Under *x*-ray treatment he has shown progressive improvement, and while he has much fibrous tissue still about the neck, he is able to carry on his usual duties and is feeling comfortable. We are hoping that this condition will continue. At any rate, his life has been much prolonged and the case has been transformed from a hopeless to a hopeful one.

CASE X. M. S., female, aged sixty-eight, referred by Dr. M. Frank, Egg Harbor City, N. J., May 12, 1921. She had noticed a tumor two months previously, involving the right side of her neck, which had grown progressively larger, and five weeks previously began to give her a choking sensation and breathing difficulty. At the time she was referred for treatment there was general enlargement of all the lobes of the thyroid, but more particularly of the right. The tumor was large, irregular in outline, not clearly defined, and infiltrated the surrounding tissue, which led us to the diagnosis of malignancy. We treated her through three portals of entry including the thyroid and upper mediastinum, and gave her four doses through each of these three portals of entry within a period of two weeks, consisting of the following technique: at a distance of 30 cm., 6 mm. of filter, 9 inch spark gap, 5 ma., twenty minutes' exposure. July 12, 1921, two months later, all visible and palpable evidence of the tumor had disappeared. However, she was given a similar dose over each of these areas during the month of July, and again during the month of September, though at no time since the first month has there been any palpable evidence of disease, and apparently she has completely recovered.

*Remarks.*—This latter case also belongs to the group in which the diagnosis is not positive, though clinically I have no doubt as to the malignant nature of this tumor, and in this last case we have obtained the most brilliant results of any. It would seem to me that with these results, as described, if a diagnosis can be made reasonably early the best possible treatment will consist of active radiation, either by the roentgen rays or by radium.

TECHNIQUE

In general, as a result of my experience in these tumors and other tumors, I believe that it is advisable to treat these patients through three or more portals of entry, according to the amount and distribution of the disease, with a focal skin distance of 30 cm., using a 9 inch parallel spark gap, 5 ma. of current, 6 mm. of filter, and with an exposure of twenty minutes, to be repeated over each area a week apart if possible and to treat each area three times, then to stop treatment completely for three or four weeks, when each area can be covered again twice in a similar manner. If the disease localizes itself to a single nodular mass which ceases to respond to further treatment, it is entirely practical then to introduce radium needles directly into the tumor tissue and thus bring about a more thorough destruction of the cancer cells in the deeper portions. Ten mg. of radium element in the form of needles can be introduced into the tumor tissue approximately 1 cm. apart and left in place six to eight hours, or 2 cm. apart and left in place twelve to fifteen hours.

CONCLUSIONS

1. Every case of carcinoma of the thyroid that has been operated upon should receive, as soon as possible, at least two thorough courses of roentgen-ray treatment, and more if the disease has not been completely removed so far as the surgeon can recognize.

2. If a diagnosis of carcinoma of the thyroid can be made without operation, a reasonably good hope of success can be entertained by radiation treatment.

3. Recurrent cases can be made to respond to treatment and the recurrence can be made to disappear, but the definite metastases are not likely to be controlled in late cases.

4. Radium can be combined with roentgen-ray treatment to good advantage in carcinoma of the thyroid when the tumor has become definitely localized or when it ceases to respond to the roentgen rays.

# ROENTGENOTHERAPY OF THE THYROID*

BY A. F. TYLER, M. D.

OMAHA, NEBRASKA

IN the discussion of this subject we shall consider only cases of hyperthyroidism, including of course under this title, the typical exophthalmic goiter, the hyperplastic type of toxic goiter and toxic adenoma. All other types of goiter should be treated by surgical or medical means rather than by roentgenotherapy.

Goiter is an exceedingly common malady in America. There are numerous areas where the disease is endemic; this is especially true in the Great Lakes region around Lake Erie and in certain other parts of the country. There is even an area in which it is endemic in Iowa and a portion of Nebraska, where practically every young woman who reaches the age of twenty-one develops goiter, generally of the toxic variety. This means that the disease is almost universal in our country, being more common, of course, in the endemic areas. The disease is so serious in its effect that the patient deserves our utmost skill in the treatment.

*Historical.* The employment of *x*-ray in treating this condition dates from 1898, about the time *x*-ray machines were manufactured in suitable form for medical purposes. The mechanical limitation of the apparatus at that time made the fractional dose method with low penetration compulsory. Even with this technique, which is now considered inadequate, many brilliant results were reported. Pfahler[1] in 1916 reviewed the literature, bringing up to date *x*-ray therapy of toxic thyroids and reporting the results of his work. Later, Holmes[4] reported the results of roentgenotherapy of toxic thyroid at the Massachusetts General Hospital and I believe

* Read at the Twenty-second Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Washington, D. C., Sept. 27–30, 1921.

he was the first roentgenologist to control the treatment by estimation of basal metabolism. Both these men emphasized the inadequacy of the low voltage fractional dose method of treatment as compared with the more modern technique, and in closing Pfahler says it has been customary for him to use a spark gap of 9 inches, anode skin distance 8 inches, 5 ma. and five minutes time over each area with the rays filtered through 3 mm. of aluminum and 1 mm. of sole leather. He recommends that this dosage be repeated once every three or four weeks and that we should treat both lobes of the thyroid and the thymus as well. This employment of *x*-rays produced by higher voltages and passed through heavier filtration marks a distinct step forward in *x*-ray therapy of toxic thyroid.

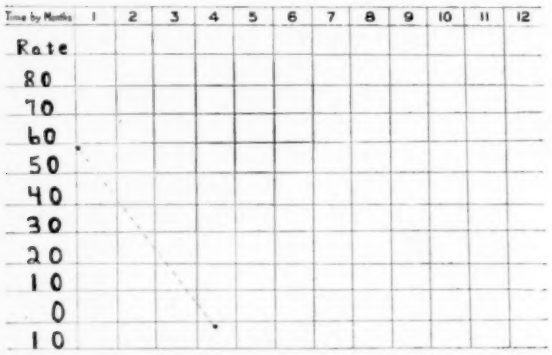


CHART 1. Mrs. W. The result of the metabolic estimation made before treatment and at the end of treatment, four months later. Notice the rapid decline from plus 59 per cent to minus 3 per cent, the patient being entirely well and free from any signs of toxicity at the time the last test was made.

*Cases Suitable.*—There are three distinct clinical types which are amenable to radiation therapy. First, the exophthalmic goiter; second, the hyperplastic toxic goiter; and third, the toxic adenoma. In our experience the response to roentgenotherapy is in the opposite order from that in which I have named them above; that is, toxic adenoma responds the most quickly, hyperplastic goiter next, and exophthalmic goiter last. This may be due to the fact that exophthalmic goiter usually comes after the symptoms have become more pronounced and after cardiac degeneration has occurred, or even after mental symptoms have begun to show.

*Method of Selection.*—Due to the fact that we must distinguish very carefully as to the type of goiter which presents itself for treatment, it is compulsory for us to use every means at our command for arriving at an accurate diagnosis. We must make a very thorough physical examination. If we feel that we do not care to undertake this part of the work ourselves, we should call into consultation a competent medical consultant who will do this work for us. Those of us who are working in close association with a group of men have the advantage of this consultation with the greatest of ease. Those of us who are working independently should train ourselves to be thoroughly familiar with the different physical findings in the different types of cases.

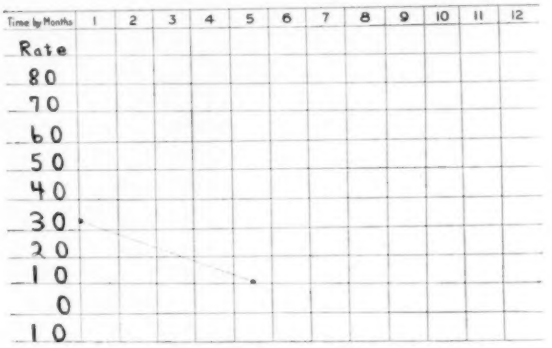


CHART 2. Mrs. F. The result of the basal metabolic estimation before treatment and at the close of treatment five months later. Notice the rapid decline from plus 32 per cent to plus 10 per cent. This patient has remained well to date.

We should examine every patient carefully for cardiac changes. This has been especially impressed upon me by a recent case of exophthalmic goiter with a history of having passed through three crises previous to coming to me. She was left a widow on a farm with several small children and for years had reared the children and managed the farm and thought she could not give up. When she presented herself to me, however, she had a typical exophthalmic goiter with myocardial degeneration, arhythmia and fibrillation. This of course presented a very serious problem and we were compelled to hospitalize her at once. Under hospitalization the heart slowly returned to normal rhythm, the myocardial changes gradually

recovered, and roentgenotherapy over the thyroid gland caused almost entire disappearance of the tumor, together with reduction in the pulse rate, a sense of well-being, and a lowering of the basal metabolic rate. This patient, however, will always have degeneration of the heart muscles and doubtless some time in the not far distant future she will die of heart disease secondary to the exophthalmic goiter.

There is another type of case which frequently presents itself to the roentgenologist, that is the one which has gone

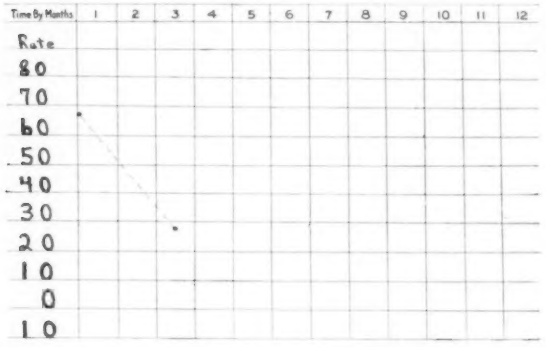


CHART 3. Mrs. H. Basal metabolic estimation before and after treatment; the first test showing a plus 66 per cent, the second test at the end of three months showing a plus 26 per cent and a third test at the end of eight months showing minus 4 per cent The patient has remained well up to the present time

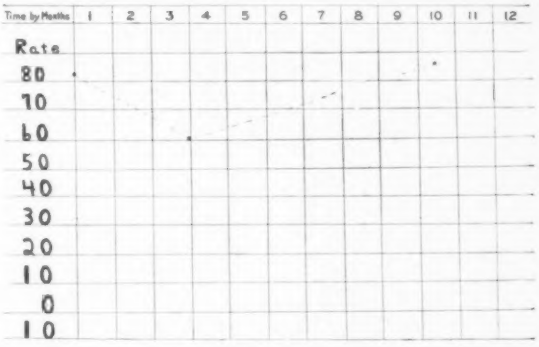


CHART 4. Mrs. L. A case of toxic thyroid showing the basal metabolism before treatment of plus 83 per cent, a second test at the end of three months of plus 60 per cent and a third test at the end of the tenth month showing a plus 85 per cent. An extreme case which has not had sufficient rest and has not responded well to treatment. The goiter was complicated by myocardial degeneration which made the case inoperable. She is still under observation.

on until mental changes have taken place. These cases are practically always fatal, no matter what treatment is administered. They are in the last stages of dissolution at the time they present themselves for treatment and tax the skill of the medical man and roentgenologist to the utmost.

Not only the routine physical examination as mentioned above should be made, but the investigation of all parts of the body for focal infections is very important. Since 90 per cent of all foci of infection which produce metastases in the body are located above the clavicle, the tonsils, teeth and accessory nasal sinuses should be especially investigated. This is of prime importance; and our experience has been that unless we eradicate the foci of infection in patients suffering from toxic goiter, they will not get well.

Our experience has also shown that there is a very close relationship between the function of the thyroid gland and the function of the ovaries. In cases in which there is excessive menstruation without any demonstrable pathology and in which the thyroid is diseased, not only do we treat the thyroid but some treatment is given over the ovarian region, aiming to check the ovarian function. In several cases in which this combination has existed, we have, for our information, treated the thyroid alone for a time to see what the result would be. When the patient did not respond with the usual rapidity to the treatment, we treated the ovarian region, and then found a much quicker response.

In addition to all physical examinations, we especially urge the employment of the basal metabolic estimation. This should be done in all cases of goiter which present themselves for treatment. If carried out as a routine it will be found of great help in distinguishing between nervousness with focal infection and true toxic goiter. It is in this type of case that it has proved especially helpful in our hands in a diagnostic way. We would not be without its use to check the effect of treatment.

Dr. Holmes has shown us the extreme value of the basal metabolic test as a check on the effect of treatment. We cannot conceive, after a case has been

worked out as here described, and the basal metabolic record shows that the metabolic rate is down to normal and remains there for a period of months, together with improvement in the general physical condition, how anyone could have any argument against the favorable influence of radiation on toxic thyroid. It has been mentioned by some that there will be a temporary increase in the basal metabolic rate for a short time after the first treatment. This occurs in the severely toxic cases, consequently we need to be a little cautious in the dosage administered in some of the cases. After this first increase in the basal metabolic rate in the severe cases, in the average case there will be a gradual decline of the basal metabolic rate until it reaches normal or slightly below. This decline covers a period ranging from three to twelve months. Clinical improvement will show earlier than the improvement in the basal metabolism; in fact, we personally feel that there should be clinical improvement in every case at the end of the four weeks when the patient returns for the second treatment. In cases which do not show this clinical improvement we feel that the treatment is going to be unsatisfactory and rather disappointing and prolonged.

Some men have mentioned that there was danger of producing myxedema by roentgenotherapy. There is no more danger of producing myxedema under proper technique than by surgery. The surgeon learned long ago that he could not remove the entire gland without getting into trouble. We should bear in mind that same knowledge and should not treat to destroy the whole gland. It is my custom, unless there is absolute need of treating the isthmus, to protect the isthmus during treatment so that it does not receive any radiation. This accomplishes two things: first, it avoids the danger of myxedema, and second, it protects the trachea and larynx from radiation. We have found that if we expose the trachea and larynx to heavy radiation, patients develop a temporary aphonia and in some cases of heavy radiation a permanent aphonia.

We have one patient who was so toxic that she was inoperable. She was referred to us for radiation treatment and improved very rapidly. After her recovery from the disease she still had quite a tumor in the neck, and because of her pride she went to the surgeon who had referred her to us for treatment and asked if he could not remove the tumor. This he did for cosmetic reasons. This patient suffered from myxedema, not from radiation treatment, but because, owing to the fibrous condition of the thyroid at the time of operation, it was completely removed, leaving insufficient thyroid tissue to maintain the balance of metabolism. We have had the privilege of making a microscopic section of this specimen, which proved beyond a doubt that radiation changed the parenchyma of the gland to fibrous and connective tissue.

Our routine when patients suffering from thyroid disease present themselves to us for treatment is as follows: First, a careful history is taken which includes all the family history, personal history, history of previous illness, previous operations and any other data which can be obtained. After this, a careful physical examination is made including blood-pressure, pulse, temperature and examination of the heart; then an *x*-ray examination is made of all the teeth and accessory sinuses and a fluoroscopic examination of the chest, together with plates in the oblique position, as recommended by Pfahler. After this is done a basal metabolic estimation is made; then *x*-ray or radium therapy is employed. It is our custom to use the *x*-ray in ambulatory patients, using a 10½ inch spark gap, 6 mm. of aluminum and one thickness of sole leather, 8 inch anode skin distance, 6 ma. of current for fifteen minutes over each area, treating three areas, one over each lobe and one over the thymus region. This dosage is repeated in four weeks and ordinarily three such doses are all the patient needs. We are very careful not to expose the trachea and larynx, unless absolutely compulsory, on account of the involvement of the isthmus.

It is our custom to employ radium therapy in cases requiring hospitalization. We do this because of the fact that we can employ radium while the patient is lying

in bed, thus avoiding excitement and the physical exertion of being taken down to the *x*-ray room. We feel that the effect of *x*-ray and radium on the tissues of the thyroid gland and on the symptomatology of the patient is practically identical.

*Advantages of Roentgenotherapy.*—In advocating this type of treatment for toxic goiter we feel that it has certain advantages over other treatment. First, there is no surgical shock, consequently the mortality is very low; second, it is useful in surgical failures; third, it can be employed in inoperable cases. In comparing this method of treatment with the surgical method we must bear in mind that the basal metabolic rate returns to normal in about three weeks after an operation, while with roentgenotherapy the decline to normal is gradual, occupying from three to twelve months.

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# DISCUSSION OF SYMPOSIUM ON THERAPY OF THE THYROID GLAND

PAPERS BY DRS. ALLISON,[1] HOLMES,[2] PFAHLER AND TYLER

Dr. Richards. I was very greatly interested in hearing the final résumé of a subject which has interested us considerably for the last six or seven years. There is nothing I can add to the discussion except to make the observation which one of our surgeons has several times noted in connection with adhesions following operation. We have had the usual criticism that long continued radiation causes adhesions which are detrimental in the operation, if that becomes necessary. One of our surgeons has made the observation that it permits him to do an almost bloodless operation and that he considers it not a great disadvantage but on the contrary occasionally a real advantage in that respect, and that the adhesions, as such, have not been a disadvantage. If I may be permitted to refer to our work, we published two years ago a series of 300 cases treated and since that time we have added about 150 other cases with, in general, the results which Dr. Holmes and the others have reported. During the last two years these were checked by metabolism tests almost invariably, and there is nothing to add in that respect except our conviction that the treatment offers in a large majority of cases quite as much as surgery, and sometimes much more. A number of cases were postoperative failures and we have been able to pull them around to a condition of apparent health. I would like to add two cases to those contained in Dr. Pfahler's paper of successful treatment of carcinoma of the thyroid. In both cases more than two years have now elapsed since the initial treatment; both were proved by operation; and both are now clinically well. The only other thing that occurs to me is that as roentgenologists we do not have the courage of our convictions. In my own work when my opinion goes up against the opinion of a surgeon, I am more likely to lose out than win out. I do not think it should be so. If we can substantiate our opinions with figures and with proof, I think we can offer to our patients quite as much as the average surgeon with much less risk.

Dr. Palmer. About two years ago I became very much interested in the thyroid question in association with the internist and surgeon. I would like to emphasize the value of the opinion of the surgeon, an opinion of one who is absolutely unbiased about this thyroid question, because I think his opinion is of great help in any of these cases.

[1] Allison, R. G. *X*-ray treatment of toxic goiter. Am. J. Roentgenol., Nov., 1921, viii, 635.

[2] Holmes, G. W. Some observations on the treatment of hyperthyroidism with *x*-rays. Am. J. Roentgenol., Dec., 1921, viii, 730.

We have been undecided as to the value of surgery in toxic adenomata. In cases in which it is impossible to bring them to the normal, or in cases in which the adenoma is giving pressure symptoms, we find it advisable to have the adenoma removed. We check these cases frequently by metabolism estimations and consider it of the utmost importance.

I would like to emphasize what Dr. Case said in regard to the dangers in some of these highly toxic cases. I believe each case should be carefully watched and studied before giving the first *x*-ray treatment and that no highly toxic nervous case should receive a full treatment without some preparation, such as the giving of morphia in the extreme cases. I have in mind a case that died in the hospital twenty-four hours after one *x*-ray treatment. Looking up the history of the case I found that there had been no metabolism estimation and that the patient had been given the treatment in a highly nervous condition, very high pulse rate with auricular fibrillation. It was the general opinion among those who saw the case that she died as the result of extreme toxemia following the treatment.

Dr. Case. It seems to me the time has arrived when we must consider the *x*-ray or radium treatment of hyperthyroid cases as well established and approved. I want to ask Dr. Holmes about adhesions following *x*-ray treatment of the thyroid. I have heard repeatedly that surgeons dislike very much to operate for goiter a patient who has had preliminary treatment with *x*-ray or radium on account of the numerous adhesions alleged to be present at the operation. In my own surgical experience I have not found adhesions to be present in any unusual amount in such cases; on the contrary one notices adhesions in thyroid operations more frequently after thyroiditis than after *x*-ray treatment. I would like to ask Dr. Holmes' experience with reference to this point.

I might also mention my experience at the Battle Creek Sanitarium in the treatment of toxic thyroid cases where the patient is so extremely nervous that a trip to the *x*-ray room would be very upsetting. We found it very helpful in those cases to use radium for the first application. It is not a bad idea to apply ice bags to the neck and throat of such cases; and it is very easy to slip a radium applicator in one of the ice bags and give the proper dose.

We are very fortunate in having as our metabolist Dr. Paul Roth, who worked with Dr. Benedict at Boston in developing the first apparatus for clinical metabolism estimations. We have utilized this method in checking up our cases since the earliest date when such a method was clinically available.

We must decide in a thyroid case whether we are going to use radiation or surgery. As Dr. Holmes said, it is not always possible to stick to our ground. If possible, we should never submit to *x*-ray or radium a case which may later need surgery for the reason that the combined procedure is far more likely to produce myxedema.

I would like to add to the list of thyroid cancer cases cited by Dr. Pfahler a patient with malignancy of the thyroid who received her first treatment from us in 1914. The patient is alive and well to date without any sign of recurrence or anything to suggest more than an ordinary goiter operation. An attempt was made to remove the thyroid. It was found to be malignant and the operation was given up when half accomplished and the patient sent to me for treatment. That was early in 1914 and to-day the patient is alive and well—free from any signs of recurrence.

Dr. Holmes. In regard to the question of adhesions, I think that in order properly to understand this condition we must consider very briefly the cause of adhesions. I do not think that this is well understood, but it is generally stated that following tissue destruction of any form new connective tissue will be produced. If this assumption is correct, some gland must be destroyed, and sufficient time must elapse for connective tissue to form before you have adhesions. We have been very fortunate to have associated with us in our work a clinician and surgeon who would cooperate. Our surgeon does not find any difficulty whatever if the operation is done within six months after starting treatment. The larger number of cases in which adhesions give trouble are those which have been inefficiently *x*-rayed over a long period of time—that is, years.

One of the arguments against the radiation of the thyroid is the length of the treatment, during which time the rapid heart continues. I think there is a very definite question as to whether or not the damage to the heart resulting from the stress of operation is not greater than that which would be brought about by the period of time before which the metabolism reaches normal.

Regarding the question of myxedema, we, as roentgenologists, are exactly in the same position as the surgeons were five or ten years ago. We do not know how much gland to destroy. Up to this year, I did not believe we could produce myxedema. I think that we shall be compelled to carry out some such technique

as Dr. Tyler suggested. I believe that adenomatous cases develop myxedema more quickly than the exophthalmic type.

In connection with the treatment of malignant goiters, I have had the opportunity to treat six cases. One received as many as eighteen treatments over the thyroid gland. I had a metabolism done and it was normal. It would seem that it is very difficult to affect the normal thyroid. This is in line with the theory that cells undergoing some pathological change are more likely to be affected by radiation than the normal cells.

DR. PFAHLER (closing). I am very glad to learn of these additional cases that have been successfully treated. I am quite sure there must be a number of other men in the room who have had experience in this line. My impression is that carcinoma of the thyroid is more responsive to treatment than almost any other carcinoma, and I believe that we have not treated enough of these cases. I believe it is distinctly the best treatment we can use. I concur with the previous speakers that in very bad hospital cases of hyperthyroidism you can probably use radium to greater advantage than *x*-rays. In ordinary toxic goiter cases my technique differs a little from that which has been previously described. I use four portals of entry, dividing the thyroid in the median line, and again dividing each side with a line extending downward from the angle of the jaw to the middle of the clavicle. I treat the anterior two fields with the patient lying on the back and the posterior two fields with the patient lying on the abdomen—directing the rays downward and inward, protecting the larynx.

# THREE CASES OF SARCOMA TREATED BY RADIATION*

BY D. Y. KEITH, M.D., AND J. P. KEITH, M.D.

LOUISVILLE, KENTUCKY

THE histories of the following cases are so unusual that a detailed report will prove of interest. You will note one case is well after five years; one after two years and one after fifteen months. Two had received all that surgery had to offer and the other was beyond surgical relief or aid.

## CASE I

*Personal History.* Female, married, aged fifty-nine; married forty years; six children living; none dead. No history of tumors in any of her family.

*Recent History.* First noticed a small pigmented tumor in suprasternal notch in April, 1913. Sixteen months later this was removed and began to show evidence of return in about one year. It was again removed, but returned in about three months.

*Diagnosis.* Melanotic sarcoma.

She came to us on January 5, 1916, and we were told by her surgeon that it was impossible at the second operation to remove all the pigmentation because it was so far behind and so deep in the suprasternal notch, which was unusually deep, the patient on account of being thin weighing about 85 pounds.

At the time we first saw her a small black mass was present deep in the episternal depression, about the size of a navy bean. On palpation it felt spongy and appeared very much like jelly in consistency. Any attempt to remove or manipulate the small mass caused copious bleeding.

She was *x*-rayed anteriorly and posteriorly at monthly intervals for six months, receiving enough to give a first degree skin reaction on three occasions before any change in the tumor was noted. The tumor had completely regressed by June, 1916 (six months after treatment was instituted), and at present there is no evidence of return. A moderate telangiectasis is present over the site of the tumor, as the only reminder of her pigmented tumor.

She had received prophylactic or preventive doses at sixty to ninety day intervals since June, 1916, receiving seven in 1917; five in 1918; four in 1919, and four in 1920. She was last seen in December, 1920, though a letter was received from her on

*Read at the Second Annual Meeting of the Central Section of THE AMERICAN ROENTGEN RAY SOCIETY, St.Louis, Mo., Feb. 21, 1921.

February 15, 1921. There is no evidence of return or transplantation elsewhere.[1]

*Technique.* At the time the treatment was instituted she was given a 7 in. spark gap; 12 ma.; 8 in. skin distance; 3 mm. of aluminum filter, no leather, and six minutes, time. Three ports of entry anteriorly and two posteriorly were used.

During the last three years the technique has been 8 in. skin distance; 5 ma.; 9⅝ in. spark gap; ten minutes time with filters of one piece of photographic glass; 6 mm. of aluminum with a piece of sole leather lying upon the patient. Only an anterior and posterior port of entry have been used during this time.

CASE II

Female, married, aged fifty-two. Wife of a physician. Family and personal history negative.

*Present History.* First noticed a growth in the left side of the neck in August, 1911. Very small, perfectly free and movable, with no pain.

*Operative History.* On January 10, 1912, under local anesthesia tumor was removed for microscopical study. Pathological report was "round cell infiltration with a few giant cells." Diagnosis: Chronic adenitis, non-tubercular.

*Second Operation.* On October 1, 1912, under general anesthesia a small keloid scar was removed with a small nodule thought to be an enlarged cervical gland, which proved to be a blood clot.

*Third Operation.* On April 1, 1913, several enlarged glands were removed which were lying just over the carotid artery.

During the summer of 1914 a recurrence was noted, and on September 30, 1914, the enlarged nodules were again removed and submitted to a pathologist whose report follows:

"The specimen from the neck shows a malignant tumor rapidly growing. Further than this I do not like to go at present, but I am much interested in the future of this case. It has some indications of being a melanoblastoma (melanosarcoma). I want to make paraffin sections and do some differential stains to determine the nature of the pigment. If it is a melanoblastoma, I suppose it might be metastatic from a tumor in the central nervous system, which has not yet manifested itself.

"If it should prove fatal, I should like very much to have the opportunity of making a post-mortem examination."

Final report October 6, 1914. Diagnosis: Melanotic sarcoma.

*Fifth Operation.* In January, 1916, she was operated upon by Dr. Coley of New York, who removed all the enlarged nodules, the largest one being about the size of an English walnut and containing a small amount of fluid. A section of the carotid artery was removed with this mass of malignant nodules.

Treatment with Coley's fluid by Dr. Coley immediately after the operation was continued for more than one year under his directions, the treatments being given by her husband. The nausea and reaction were always severe, the patient finally refusing to continue the injection of toxins.

On January 25, 1918, another small nodule was removed about the size of a shelled peanut with the following pathological report:

Specimen consists of a tough mass of white and red tissue 45 × 22 × 12 mm. Section reveals several white glistening lymph nodes, cut surface of which is not remarkable. The largest is 22 × 17 mm. This node has in it a spherical mass 7 mm. in diameter which is harder than the remainder of the gland and irregularly speckled with white and gray.

*Diagnosis.* Melanotic sarcoma, metastatic.

She came to us on June 5, 1918, four months after last removal of a small nodule. On examination a well-elevated scar 3½ inches in length was seen on the left side of the neck anteriorly. The scar was about ½ inch in width and in the margins of the lower end were several small nodules, the size of shelled peanuts, fixed, with moderate tenderness on pressure.

*Technique.* 105 kv., equal to 9⅝ inches

[1] This patient was seen again on December 14, 1921 and is in good shape physically, though having suffered a hemiplegia in December from which she has completely recovered except the delicate movements of the hands.

spark gap; 8 inch skin distance; 5 ma. current; one photographic glass; 6 mm. aluminum and sole leather filters by the cross-fire method.

She was given divided doses every second day until full treatment was completed. The entire cervical area was covered anteriorly, laterally and posteriorly. Treatments were given at monthly intervals for one year. All the small nodules had disappeared within sixty days after treatment was instituted with marked thinning of the thick scar.

Thirty-three months have now elapsed since treatment was begun and twenty-one months since the last cycle was given.[2]

It is reasonable to believe that after so many recurrences with such marked relief from proper roentgenotherapy, relief and probably cure could be obtained in cases of this character without surgery. It is certain that if the growth could be inhibited it would be much easier for the patient.

These two cases of pigmented tumors are of great interest because of the long period of years over which they have extended, because both are at present free from evidence of recurrence and neither has ever been transplanted to other portions of the body. We are aware that you have seen many cases of this type that give very little if any response to radiation, either roentgen ray or radium.

Both these cases were given more than the erythema dose, which we feel has to be given in order to obtain a lethal dose for the structures beneath the skin. The deeper the nodules are beneath the skin the more absorption of the ray; hence, in order to obtain a lethal dose to the tumor mass as many ports of entry are used as it is possible to obtain.

CASE III.

Female, single, aged forty, white. Housekeeper.

*Family History.* Father living and in good health. Mother died of malignancy of axilla, developing from a small nevus. Has two brothers and four sisters living in good health. No history of tuberculosis or lues.

*Previous History.* Always healthy, of a robust physique and blonde complexion.

*Present History.* During August, 1919, patient says she experienced severe pains in the right arm after having used a sledge-hammer in breaking wood. Several days later the right pectoral muscle became swollen, infiltrated and very painful. She was treated for pneumonia, and after changing physicians two or three times she was referred to us for an opinion as to what she might expect from roentgenotherapy.

On examination we found a very robust patient; weight 160 pounds. She had lost 30 pounds during the past two months and had been taking opiates for the relief of pain. A mass, the size of an orange, was found in the upper half of the mammary gland, extending outward into the pectoral muscle with so much induration that it was impossible to determine whether the tumor was in the gland or in the pectoral muscle. The glandular enlargement in the axilla was marked. Edema of the entire arm was present but particularly marked in the hand. The movements of the shoulder and forearm were very much restricted, the least motion causing a great deal of pain.

Her physician and family were told that our opinion was that she had a sarcoma which, it was quite evident, was inoperable and that radiation offered her relief of pain for a short time and probably some reduction in the size of the tumor, and that with their consent we would use larger doses than was our custom, but no larger than we would use on any other patient with the same type of tumor.

Exposure over the anterior portion of the right chest, which included all the tumor mass, gave a skin reaction that was quite severe and caused us to reduce the dose on the posterior areas treated two days later.

Patient received treatment on the following dates: January 15, 17, 29, 31; February 17, 19; March 15, 18; May 3, 5, 24, 26; August 26, 28. She has been advised to see us at regular intervals of three months for the next two years.[3]

She was given a cycle of treatments on November 24–27, 1920, and at that time

[2] This patient is well and free from recurrence, January 10, 1922.

[3] This patient was in for prophylactic treatment November 2, 1921, and is well at the present time.

was completely free from any enlargement in the pectoral muscle. A symptomatic cure has been present for one year. She will be given radiation every three months for two years if she adheres to our advice. The pain was relieved within one week and has not returned. The edema in the hand and arm has completely disappeared, and there is no evidence at present of tumor in axilla, muscle or gland. When she returned in March, two months after the beginning of treatment, she insisted she was well, and it was only after a great deal of persuasion that she promised to return. She has completely regained her original weight (loss 30 pounds). There is no loss or restriction of motion in the arm or shoulder.

The points of interest in the technique in this small series is the difference in voltage which ranged from 7 to 9⅜ inch spark gap and in the filters: one patient received a filtration of 3 mm. aluminum, is well five years after beginning of treatment. The others received filters of one piece of photographic glass; 4½ and 6 mm. of aluminum with one thickness of sole leather with a spark gap of 9⅜ inches; voltage 105 kv. with no difference in the ultimate results. We believe there is one point to obtain in all cases; a full lethal dose for the malignant cells with as little injury to the skin points of entry as possible.

With the aid of radium needles to insert in local masses or recurrent nodules we are confident most types of malignancy can be handled with much less suffering to the patient, with more cures, than with radical surgery and inefficient radiation, as is usually the case when supervised by the surgeon.

The future in malignancy, we believe, will be in cosmetic surgery, *x*-ray externally, radium needles inserted in the drainage, lymph nodes or recurrent nodules, preferably supervised by the roentgenologist, as most of us have seen patients come back to us after radical surgical procedures where we had expected cosmetic surgery and find on examination that they are hopeless and much worse than if no surgery had been attempted.

Our experience with filters is that when erythema appears, it heals quicker with less annoying symptoms where heavy filtration has been used.

# THE SUPERFICIAL REACTION OF RADIUM AS A GUIDE TO DOSAGE*

BY WILLIAM S. NEWCOMET, M.D.

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THERE seems to be a prevailing opinion in the medical profession that if a person possesses a given amount of radium it is possible to employ it for almost any lesion coming under observation. While this may be true to some degree, the best results will be obtained where the application of radium is made to fit the case, and not in accordance with the amount of the element the individual possesses. The more flexible the radium unit is, the better will be the results, and where it is only possible to obtain a limited amount of this element, several small units will be much more useful than one of larger size.

The acme of perfection would be reached if it were always possible to give the amount of radiation at one sitting that would completely heal the lesion treated. At the present time our dosage factor is so irregular that to carry out this procedure is almost impossible. In mentioning this fact, the cases of superficial epitheliomata must be excluded, as the majority of these heal easily under any form of radiation. Many have been observed that completely healed from a sub-erythema

*Read at the Sixth Annual Meeting of THE AMERICAN RADIUM SOCIETY, Boston, June 6–7, 1921.

dose. But where the disease has involved the deep structures, the treatment is always a most difficult and interesting problem. Many cases have been treated by radium where the dosage was not sufficient to produce the desired result. There would follow a local abatement in one area and a progression in another. Where this condition prevails it is best to stop all forms of radiation for several months and then make a new start. Such cases will respond better than those that have been previously subjected to excessive radiation, and where the tissues are breaking down from that cause, it is almost impossible to get a new start. Therefore, the application of a massive dose of radiation must always be given with the greatest care and only under circumstances where it is absolutely justifiable.

The reaction from radium has not been considered as dangerous as that of the *x*-ray, but it must not be forgotten that radium will give practically the same results under similiar circumstances. The radiation differs but the results produced are similiar and the modification is due, in a larger measure, to the difference of application rather than to the difference in radiation.

With the *x*-ray the standard is the "erythema dose," usually worked out by certain factors for distance from the anode and amount of current. In superficial conditions, the "erythema dose," although it does vary within limits, is a safe working basis due to the fact that the erythema produced is usually of a mild degree. But here we have the point of origin almost constant; the anode is always a given distance from the skin. With radium, however, the factors are different and the results upon the tissues depend upon the following conditions:

1. The amount of radium element or its equivalent.
2. The distribution of the radiating material.
3. Time of application, duration and intervals.
4. Distance from the part.
5. The style of container, filters, etc.

Any modification of these factors will produce entirely different results. If 100 mg. of radium element in a small glass tube contained within a silver tube about 1½ cm. long, 3 mm. in diameter, the thickness of the silver being about 1/10 mm., be applied for one hour; 50 mg. applied for two hours; and 25 mg. applied for four hours, in capsules of the same character, all filtered by 1 mm. lead and a thin sheet of rubber, each separate application will amount to 100 mg. hours, and practically under the same conditions, yet the effect will be quite different so far as the reaction upon the skin is concerned and likewise its deep effect must also vary. The 25 mg. for four hours will give a more intense

FIG. 1. Shows results from 100 mg. for one hour, 50 mg. for two hours, 25 mg. for four hours. Radium element in a silver tube, filtered by two layers of gauze and one of thin rubber. Eight weeks after application. Most intense reaction was observed about three weeks after application.

reaction over a larger field; in other words there will appear to be an accumulative effect. The erythema produced by the 100 mg. tube will be an oval area about 1½ by 2 cm., while the 25 mg. tube will produce an area of erythema of about 2½ by 3 cm. with an intense central reaction. The erythema usually

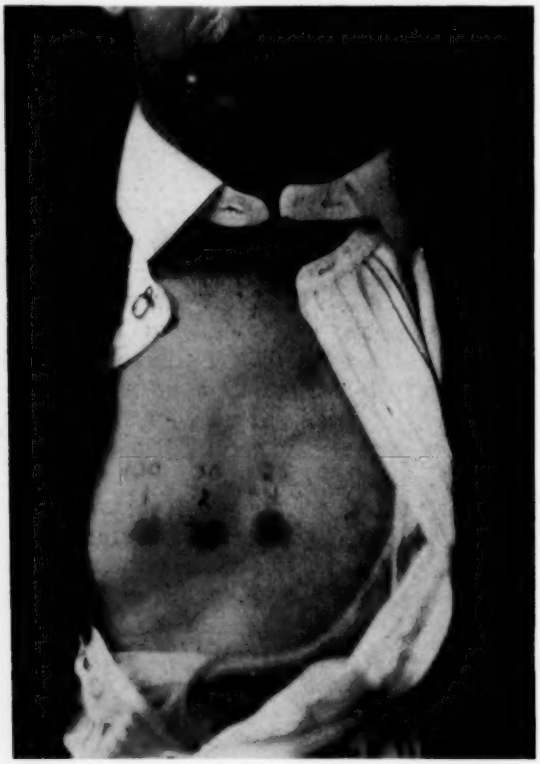

FIG. 2. Shows results from 100 mg. for one hour, 50 mg. for two hours, 25 mg. for four hours. Radium element in silver tube, filtered by 1 mm. lead and 1 layer of thin rubber, twenty-one days after application.

appears and reaches the climax within a week; in ten days, there will be some vesication, followed by a superficial ulceration, which will heal in about six weeks to three months, leaving an area of less pigmentation which remains more or less indefinitely.

If the application is modified by placing 1 mm. of lead and 1 cm. of wood between the radiating material and the tissues, and the time increased, two hours for the 100 mg., four hours for the 50 mg., and eight hours for the 25 mg., a very wide difference will be noted. In about a week to ten days the area of erythema will appear to be at its height, the area being about 2 × 3 cm. where the 100 mg. had been applied; an area 3 × 4 cm. for the 50 mg. and 4 × 5 cm. for the 25 mg. tube. The local irritation will be far greater in the area where the small tube has been applied, while the erythema that develops by the 100 mg. application becomes quite dusky; usually there will be no ulceration; the 50 mg. tube produces in some instances a slight vesication and even a slight superficial ulceration at times; while the 25 mg. tube is followed by somewhat more severe local reaction in all trials and at times an ulceration almost of the first degree. While the dosage in each instance was 200 mg. hours filtered by 1 mm. lead and 1 cm. wood, yet the local reaction was far different. If the application be again modified by placing 2 cm. of wood between the radium and the skin, the 1 mm. lead filter and time being the same as in preceding series, it will be found that the reaction for the 100 mg. for two hours produces an erythema of less intensity but wider in area or about 3 × 4 cm. in diameter. The area of erythema for 50 mg. for four hours was about 5 cm. in diameter; while the 25 for eight hours was about 7 cm. in diameter with no vesication or ulceration. This illustrates the fallacy of expressing the dosage alone by milligram-hours.

In the first series the difference in the effect of the radium might be assigned to what may be termed an accumulative dosage; but the second and third series bring in another factor, that of distance, which appears to explain the rather wide difference in the reaction obtained from the *x*-ray. The further away the source of activity is from the area of application, the more uniform will be the surface radiation, while deep dosage suffers less variation in accordance with the law of dispersion. Therefore, if a beam of high *x*-ray is passed through a port of given size, the difference between the surface dosage and that 4 cm. below the skin will not be as great as where radium is applied directly to the skin. In the case of radium it can be easily seen that there is an enormous surface dosage, while 4 cm. below it is compara-

tively small. In the treatment of superficial conditions this factor is the most important one. The diseased condition receives an enormous dose while the sound tissues underlying the lesion receive comparatively little radiation.

If the lesion penetrates to some depth and a deeper radiation is required, then the radium should be elevated and the time increased in proportion. But, should this elevation be more than 1 or 2 cm. other factors must be considered. In those cases in which the cross-fire treatment is adopted the radium should be elevated 1 or 2 cm. from the skin; and while some authorities have expressed the belief that radium is not effective beyond 2 cm., yet in the number of cases of carcinomata of the larynx, the only ones living to-day without manifest evidence of disease were those treated by this method. Others, where there was a direct application to the larynx or by needles inserted into the growth, failed to respond.

Intense local reaction has been attributed to secondary radiation; but there is not the least doubt that most of this irritation is simply due to the relatively high surface dosage.

The small amount of damage done by the secondary radiation is scarcely negligible, and the judicious use of distance will to a great extent set aside all local surface irritation.

The distribution of the radiating material must also be taken into consideration. The effect of a large tube containing 50 mg. of radium element mixed with a large bulk of non-radiating powder will produce an entirely different local effect compared with a small tube of highly concentrated element or a small tube of emanation. Therefore the factor of radiation must be worked out for each unit and the dosage arranged in accordance with the reaction produced. While we have a difference in the distribution of the radiating material, in reality the factor is only one of distance, and if the effects be compared they will be found to resemble each other more closely as the skin distance is increased.

Filtration is a most important consideration in the local application of radium. If the beta radiation is not removed, the surface radiation is so great that it will

FIG. 3. Shows results from 100 mg. for two hoursl, 50 mg. for four hours, 25 mg. for eight hours. Radium element filtered by 1 mm. lead, 2 cm. wood. Three weeks after application.

FIG. 4. Result of one application 100 mg. Radium element in silver tube placed in the center of the opening, which was covered with a fungoid mass that nearly closed the opening. Previous *x*-ray and small applications of radium failed.

cause a superficial ulceration by a comparatively small dosage. To illustrate this fact, a number of tests were made: where one tube containing 50 mg. radium, the capsule being the same as previously described, was filtered by 1 mm. lead, another was filtered by a piece of soft wood of the same thickness. Applications were made for one hour and an hour and a half. Where the lead filter was used only a very faint erythema was produced, which reached its height at the end of ten days or two weeks. Where the wood filter was used the erythema was quite marked and a week later had formed a small ulcer about 1½ cm. in diameter, which required about six weeks to heal. The reaction resulting from low radiation of radium differs to a marked degree from that produced by the high or gamma radiation. The erythema is more superficial, is usually a bright red and can be removed by light pressure; while that of the gamma radiation is usually a dusky red, is deep and difficult to remove by pressure. Likewise the ulceration, if it should follow the beta radiation, is superficial, and will heal in a comparatively short time; while the gamma ulceration is deep and the time for healing is prolonged.

Usually in those cases where there is an ulcer covered by deep granulating or proliferating material about 1 or 2 cm. deep, if radium tubes are used in the treatment they need be only lightly filtered, and the tube placed directly upon the granulating mass, which in itself acts as a filter and allows the base to be radiated by the more penetrating rays. If the mass is covered by sound skin, then the choice will lie between the use of penetrating rays by cross-fire method, trying to avoid injury to the overlying parts, or by the use of needles placed directly in the mass. The election must be left to the discretion of the operator.

The element of time as a factor must be considered according to the area covered and also with areas in the immediate vicinity. There appeared to be little or no difference between areas exposed to 50 mg. radium element in a silver tube and the same quantity in a group of stock needles, when applied to the skin for one hour. Usually there was a marked erythema in ten days followed by a slight ulceration lasting about two months. The area was an oval about 1½ cm. in diameter; and it should be stated that the tubes were protected by two layers of gauze and a sheet of thin rubber tissue. If a lead filter be added 1 mm. thick, then 100 mg. can be applied for one hour, and usually only an erythema will result. The time and area must be considered when the cross-fire method is to be employed and the 2 cm. limit of useful radiation is not to be depended upon in making the calculations. If a mass with a base 5 cm. in diameter is to be treated, one application is made at the apex and seven about the base; probably there will be a very violent reaction at the apex of the mass due to the constant radiation from all sides and the supposed equal dose by the 2 cm. limit. The element of time in proportion to distance and space to be covered is always a problem. It may be worked out by "rule of thumb" yet it is always difficult of approximation.

A rather interesting and unexpected result was obtained in the treatment of a cystic goiter. The mass projected in front of the neck about 2½ cm. and was about 5 cm. in diameter; 100 mg. radium was applied filtered by 1 mm. lead and 1 cm. wood, for two hours, in four positions, two on the right side and two on the left side of the mass. Two weeks later there was a faint erythema over the whole mass, while at the end of two more weeks the area midway between the areas of application, about 1½ cm. in diameter, was covered by dry scales, which shaded off into a dusky red area. The site of the applications still showed a faint erythema. Two weeks later the whole process had disappeared leaving only a slight tanning of the skin.

This illustrates the usefulness of cross fire, and it would appear that the area so treated is affected to a greater extent than is usually supposed. It has been shown, as previously mentioned, that the effect of 100 mg. hours given 25 mg. for four hours is more intense and extends over a greater area than 100 mg. for one hour. In conjunction with the case just cited, would it not ap-

pear that cross-fire effect was somewhat above the usual calculated factor; time being the element that alters the result? The *x*-ray burn caused by the old low-powered gas tube depended to some degree upon this factor, while the time was relatively short compared with the application of radium; yet it must be admitted that modern technique has decidedly shortened the time of exposure.

The character of the tissue must always be considered, especially where the parts have been subjected to previous irritation from other causes, and some late reactions and ulcerations have been noticed from the application of irritants after radiation: iodine, mustard and excessive heat are common, and due regard must also be given to the tissues in the very old and very young. There seems to be a prevailing opinion that it is safe to make a second application after the lapse of three weeks. But in the light of some very late reactions that have occurred, it is difficult to come to an exact conclusion. In the folds of the axilla and groin the reaction is greater, possibly due to the mechanical irritation of sweating, rubbing or chafing.

The foregoing deductions apply to normal structures where more or less uniform results are produced, yet there is some variation in the degree of resistance; but when it comes to pathologic structures the variation is far wider than it is in normalcy. To illustrate this fact attention is directed to the ordinary wart that appears and disappears under circumstances that no one has as yet clearly defined. We have seen them resist the most approved methods and vanish like magic under the treatment of some charlatan. Yet these are peculiarities of pathologic tissues. Passing from warts to well-defined tumors, some of us have seen large tumors disappear or become quiescent under circumstances that could not be explained, while on the other hand, in spite of all that could be done many of these cases pass rapidly with literally no change in their course that might be attributed to treatment.

The small superficial epithelioma need no comment, except to state that any form of radiation properly applied will heal them promptly and with practically no scar. But when they have reached the deep structures or are of the glandular type, their treatment is often difficult and must be carried out with the greatest care. Under such circumstances, the radiation must reach the deeper structure without involving the surrounding normal tissue which by its destruction would produce a field for further irritation. To obviate the damage of normal tissues where large doses are required, the implantation of radium in the growth, where it is possible, appears to be the best procedure. In this way the growth is radiated to a greater extent while normal structures are decidedly less affected. Here again judgment must be exercised, for as much injury may be caused by the introduction of radium into the mass through the normal tissues as would be done by the rays passing through it. The surrounding structures must be always considered. An "application" that would be perfectly safe in one portion of the body would mean disaster to another. To illustrate this point we would call attention to the practice of placing a 100 mg. tube in the uterus for the treatment of carcinoma; yet when this same dose is applied in the rectum for the same condition, the result is usually quite the contrary, due to the difference in the character of the disease and the structure of the intestine. In the case of the uterus, the thick heavy tissue acts as a filter and keeps the normal structure at a safe distance.

Having called attention to a certain irregularity in the response of different tissues to radiation, the action upon several cases of sarcomata which were supposed to be enlarged glands might be mentioned. When radiation was applied they disappeared easily leaving absolutely no trace of them; their disappearance was unfortunate, for within a short space of time they had reappeared in other parts usually in the deeper structures with fatal results. Therefore when a nodule is treated, it matters not how sure we are of our diagnosis, it will not be amiss to regard it as a sarcoma until it is proven otherwise. By so doing we may save life.

This article does not pretend to enter into any scientific detail as to exact measurements, nor upon any microscopical study of tissues in various stages, but is based upon a large number of applications to prove some facts which were observed in the ordinary treatment of a large number of cases.

The statement of a well-known physicist that "if men would give their dosage in their work we might come to some conclusion" cannot be denied. The dosage factor must be worked out upon clinical lines and not in the laboratory. The wide variation of the effect of radiation upon diseased tissues is a variable factor and in ending, I wish to emphasize the importance, in reporting cases, of the details as to the amount of radium, its distribution, time of application and, if repeated, the different intervals with the filters and distance from the affected part. If radium is implanted the exact method should be described, not only the amount but its distribution; the reaction observed and the relation of the diseased to healthy parts and also the results obtained. And it must be remembered that each applicator has its own dosage.

DISCUSSION

Dr. Henry Schmitz. The paper impressed me for the reason that Dr. Newcomet dwells on the erythema dose. If we realized the importance of exactly determining the erythema dose we would all get busy as soon as we return home and try to get the proper erythema reaction. The question arises whether the faint reddish color is an erythema dose, or whether we should have this go on to scaling of the skin, with loss of hair, and after four or five or six weeks a deep tanning of the skin. We must of necessity have an absolute understanding of the extent of this reaction. After we have obtained this erythema skin dose (and we have an instrument for determining it which we use with an ionization that anyone can make) we can obtain good results. We could then by the discharge of this electroscope actually determine the amount it takes to produce the erythema skin dose. The skin dose is best compared to the old-fashioned sunburn. We get the intense reddening, even the intense sensation of burning in the skin, and in very sensitive persons there is even blistering, while in the ordinary individual within a week or ten days there is the well-known feeling of the sunburnt skin, the itching and burning, etc., depending upon the length of the exposure. This is the reaction we should obtain from the erythema skin dose. Different people have a different sensibility to rays and this differs practically 20 per cent either way. Some will stand 20 per cent more than others without any reaction, while in other cases you cannot under ordinary circumstances produce this effect, or if you do it is only with remarkable difficulty.

For illustration, in one case of skin cancer, we warned our patient beforehand that there might be a burn and this was done in the presence of other persons so that there could be no misunderstanding. We stated that ordinarily there was no trouble but that if the skin was oversensitive there might be a burn. In this individual we got an overdose of almost 5 per cent. She was a fair blonde, but nothing happened and she recovered nicely within a short time. In another patient whom we did not care to treat at all because the disease was so far advanced that we thought the case was entirely hopeless, the patient received an average dose and apparently stood it well. There was no skin reaction and no improvement in the local condition. She had a persistent leukopenia. She kept on bleeding and kept on going down. Finally, after about two months, we suggested another course of treatment and wished to do a transfusion for the leukopenia, for we were afraid to treat her. She went to the country for a rest and after about four to six weeks she returned with her blood picture normal. She then had the second treatment and following that she was normal, or at least greatly improved, but she had no reaction on the skin. If with the production of the erythema skin dose we had dared to use another treatment I am sure we would have had a burn in this case of the third degree any time within six months. So this patient must have had an undersensitiveness that amounted to 200 or 300 per cent.

The thing I derived from this paper was the determination of the biological skin dose which must be the unit of comparison for our work.

Dr. Rollin H. Stevens. I would like to say a word concerning the different strengths of radium. My experience has not been very large, but Dr. Pancoast mentioned angioma. For the last ten or eleven years I have been treating cavernous angiomata with small plaques, 1 to 2 mg. of radium distributed over about two and a half, and the other to 1 cm., with the 2 mm. plaque and two sheets of paper, and I get quite a marked erythema dose, one that

will be red in about two weeks and that later will turn brown and peel, and in some sensitive places, like the face of a child, I have had some glistening. I apply it for seventeen hours. I have found that the application of these plaques has given me better results than the application of the 15 to 20 mg. plaques, and furthermore the scarring in the skin seems to be much less. I think the cosmetic results are much better. I have even treated large rhinophyma of the nose with these two plaques and have succeeded in reducing them almost entirely. I think we must use a good deal of judgment as to the strength of the radium we are going to use in the different diseases we are treating.

This treatment, of course, applies to the cavernous type of angioma only, not to the ordinary nevi.

Dr. C. J. Broeman. I wish to ask whether you ever use radium in tubes or needles in the treatment of superfluous hair, particularly in the so-called "bearded women" and on the upper lip where we know the electric needle is apt to leave some trace of scarring. I have treated several cases, using a deep filter, and in some cases I have been able to remove the hair without any bad after-results, sometimes without even an erythema dose.

Dr. Frederick Bryant. I would like to know what experience the Doctor has had in the treatment of lupus.

Dr. William S. Newcomet (closing the discussion). The statement that we can with perfect safety make a second application to a given lesion at the end of three weeks is not correct even when there is not the least sign of reaction. I think this has the approval of many medical men. Much depends upon how the first application has been, and we must look out for late reactions. I have seen reactions that were very pronounced six weeks or two months after the application of radium, when the skin appeared to be absolutely normal at the end of three weeks. Furthermore, it seems to be the opinion of many that a dosage of equal mg. hours will give the same effects with no difference as to how you distribute your radium.

I wish I could come to some conclusion as to what is the erythema dose for any given applicator at any given distance. It is by no means as constant as the *x*-ray factor. For our *x*-ray, though, the regularity of a good dose is fairly constant. We thought machines and the Coolidge tube gave us the regularity of the erythema, and I believe that some years ago someone made the statement that an *x*-ray burn was prima facie evidence of neglect. One can hardly agree with this rather strong statement, particularly when we can prove that the erythema dose is an undetermined factor.

In the treatment of angioma a number of cases have been complicated with superfluous hair; usually it is easily removed. Dr. Broeman has the right idea. If you can get rid of the hair without any marked reaction, you will have no scarring, and it is usually permanent. Excessive reaction, however, with ulceration from radium usually gives an area of decreased pigmentation surrounded by a line of increased pigment which may disappear in time depending upon the character of the skin and intensity of the burn, and the dose which will produce an erythema in one person may produce vesication in another. One must be very careful not to get an ulceration. The line between these skin reactions is a very narrow one, and peopel who desire to have hair removed do not desire a scar.

In regard to lupus vulgaris, Wichmann of Hamburg found that the majority suffered from recurrence. These cases usually respond very well to treatment, but the patients should be informed that it is likely to recur.

# TREATMENT OF BRAIN TUMORS BY RADIATION*

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BRAIN tumors are peculiarly adapted to treatment by radiation, for many reasons. A large proportion of them are made up of pathologically malignant cells and are, therefore, susceptible to the action of radium or roentgen rays. They are, as a rule, comparatively slow in growth and rarely metastasize, thus uniting two ideal conditions for such treatment, especially when it is considered that here, and in practically no other part of the body, it is safe and it is good surgical practice to remove a malignant growth in part only and leave its subsequent destruction to radiation. A localizable and accessible growth may be exposed and then be either left intact or partially or completely removed, and treated subsequently by radiation, by direct implantation of radium or by cross-firing through the skull by radium or roentgen rays, or both methods may be practiced. If a tumor cannot be localized, or it is inaccessible to the surgeon when localized, there is still left the possibility of obtaining fairly satisfactory results in some instances by cross-fire radiation from the outside alone.

The dangers attending the treatment may be considered under those of the surgical procedure, including a possible removal of the tumor; infection carried by the radium needles or implanted tubes or dependent upon leaving the wound open for the purpose of their removal; the effect upon the flap and subsequent healing as a result of external cross-fire radiation; and the effect of radium radiation directly upon normal brain tissue. Surgical dangers need not be considered here except for commenting that the very fact that radiation can be relied upon may in some instances render the operation less hazardous because complete removal of a growth may not be so essential if it is likely to be attended by added risk to the life of the patient.

The possibility of infection deserves careful consideration. Radium needles and capsules containing radium or its emanation for implantation can readily harbor dangerous infecting organisms for a long time and cannot be sterilized by heat when the radium or emanation tubes are in them. We advocate the immersion of needles or capsules and their threads in 40 per cent formalin for at least one half hour and then in 95 per cent alcohol for forty-five minutes, before they are used for implantation in the brain. More recently we have been sterilizing needles by careful boiling. In only one possible instance has an infection followed brain tumor implantation, and that was before the present method of sterilization was instituted. Infection due to leaving a part of the wound open for removal of implanted radium cannot be positively eliminated, but its avoidance must be a part of the surgical technique.

Cross-fire radiation through the scalp must usually include exposure of the surgical flap, as this is in the majority of instances the part of the surface of the head nearest to the growth. It is quite possible to jeopardize the integrity of the flap by such exposure if immediate radiation is applied. As rapid recurrence and metastasis are not likely, it is safe to postpone cross-fire radiation until healing is well under way. As the dosage given is a safe skin dose under ordinary conditions, necrosis of the flap is a remote possibility if the application is postponed for a short time. The presence of the hair must not be permitted to interfere with the application, nor should the strong possibility of its removal be allowed to weigh against the amount of treatment necessary. The patient should, of course, be warned of the likelihood of losing all or a part of the hair in the area exposed, especially in the part of the scalp included in the flap.

The possibility of dangerous effects from radiation of normal brain tissue demands

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separate and careful consideration. The technique of radium treatment of tumors must really be based largely upon the known ability of the normal brain structure to withstand definite amounts of radiation by both implantation and external cross-fire applications. Normal brain tissue is probably as resistant to destruction by radiation as any other tissues of the body, but the exact nature of the direct and indirect effects of destructive doses are serious and must be thoroughly realized and understood.

All cases treated by us have been on the service of Dr. Charles H. Frazier at the University Hospital, and all treatments have been carried out in cooperation with him. In the earlier cases treated in 1914 and later, the technique was carried out more or less at random, without the least accurate knowledge of the effect of radiation upon normal brain tissue. Implantation dosage was based entirely upon a knowledge of the approximate dosage required to destroy a similar growth of the same dimensions elsewhere, modified by an intuitive apprehension of possible danger from brain destruction and a desire to minimize destruction of normal tissue. The limit for cross-fire radiation was skin tolerance. It soon became apparent that more accurate knowledge was essential, based upon animal experimentation rather than upon clinical experience.

During the session of 1919–20, experimental work upon the brains of dogs was turned over to three senior undergraduates in the Medical School of the University of Pennsylvania—Drs. Williamson, Brown and Butler. The results of their work have been published.[1] The salient features of their experimental work were briefly as follows: A 50 mg. tube of radium element in a platinum capsule of 0.4 mm. thickness was laid directly upon the dural surfaces of the brains of dogs near the motor cortex—in the parietotemporal region—for varying periods up to a dosage of 900 mg. hours without untoward effects and without paralysis. At the end of one month, each dog was killed and the exposed area of brain examined macroscopically and microscopically. Microscopic sections of the brains exposed to 900 mg. hours' radiation showed three zones of reaction surrounding the position of the tube. In the central zone, 5 mm. wide, the brain tissue was completely destroyed; 2 mm. further out there was a hemorrhagic area with extravasation; and 1 mm. further was a zone of inflammatory reaction. The flap was not destroyed. One 900 mg. hour dog was kept alive for nine months and was then killed, and the brain showed an area of cicatrization 15 mm. in diameter with a central crater containing what was probably a clot. These experiments showed that it was practically safe to give a dose of 900 mg. hours with well filtered radium on the surface of the brain. Advantage was subsequently taken of this knowledge in the treatment of a case of extensive epithelioma of the external ear, canal, middle ear and mastoid in which direct applications were made to the involved tegmen of the attic and antrum. The experiments of Bagg with implanted unfiltered radium emanation would lead us to believe that such a dose without filtration would be dangerous.

Further experiments were required to determine the maximum tolerance to surface applications and to implantation into the brain, whereby the entire output of radiation would be exerted upon the brain tissue. In surface applications probably little more than half the radiation acts upon the brain. Sudden death had followed direct implantation in two cases of brain tumor, but not necessarily the result of the radiation. One of these was an hypophyseal tumor.

During the past year, at the request of Dr. Frazier and myself, my associate, Dr. Pendergrass and three senior undergraduate students, Messrs. Hayman, Houser and Rambo, have carried out a series of experimental applications ostensibly for the purpose of determining the maximum safe surface dose and implantation dose in dogs' brains and the surface dose upon the spinal cord. We will quote the results of their experiments only as they apply to the points under discussion. The combined results of their work have brought out many points of value and

[1] C. S. Williamson, R. O. Brown and J. W. Butler. A Study of the effects of radium on normal brain tissue. *Surg., Gynec. & Obst.*, Sept., 1920, xxxi, 239.

intense interest, and will shortly be published by them.

The smallest surface dose given was 1,000 mg. hours with 0.4 platinum filtration over the same area. The dog was killed on the fourteenth day, prematurely. The next higher dose was 1,150 mg. hours, and the dog was killed on the forty-ninth day and had shown no untoward results. The next higher dose was 1,400 mg. hours, and that dog developed a progressive paralysis and died in four weeks. The largest dose was 2,600 mg. hours, followed by death on the sixth day. Between these death doses there was found to be almost a direct relation between the dose and the time of death, which could be practically prognosticated by the intensity of dosage. The cause of death and the interesting antemortem phenomena will be fully discussed by the authors in their report.

Upon the basis of these experiments the human brain surface dose of fairly well filtered radium when concentrated over a comparatively small area should not exceed a figure between 1,150 and 1,400 mg. hours, when healthy brain tissue is exposed directly and had better be well below 1,400 mg. hours. Because of the comparatively small surface of the dog brain it is difficult or impossible to determine whether or not a larger dose can be given with safety if spread over a larger area. It probably could be, especially if a decidedly destructive dose was not delivered at any one point. This assumption finds credence in the fact that much larger doses are given over a large part of the head by external cross-fire radiation, and each area receives less than a destructive dose to the skin. No one expects to expose any one limited area of healthy brain surface of the human to such a dose as 1,400 mg. hours, but these danger figures are of value when one computes what dosage normal brain tissue is likely to receive in a limited area during the treatment of a brain tumor with a certain implantation dose.

As would be expected, the safe dose from *implantation* is much smaller than the safe surface dose. Implantation of filtered radium in dogs' brains from 900 mg. hours down to 360 mg. hours all resulted in death, with apparently the same manifestations in each instance, but not resulting from any local infection. The therapeutic dose from implantation must be comparatively small, therefore, when actual destruction of normal brain tissue is likely to result. The well filtered dose can probably be higher than the unfiltered dose, and tumors act as filters in protecting the normal tissue. Implantation of needles around the periphery of a tumor is probably more dangerous than central implantation. In every instance Dr. Frazier has employed central implantation. We have given as high as 1,445 mg. hours by implantation in a large cerebellar tumor without untoward results, and the patient is still alive seven years after the application. In another case, a 900 mg. hour dose was applied in a cavity the size of an egg following the removal of a cerebellar tumor. Implantation doses of from 900 to 1,050 mg. hours were applied in six other cases, and none of them died as a result of the applications with the possible exception of one who died fifteen days after an implantation dose of 1,000 mg. hours. It is more likely, however, that death was not the direct result of the radium application. Nearly all of these cases received supplemental external cross-fire radiation.

No experiments have been carried out to determine the effect of external cross-fire radiation upon dogs' brains for the reasons, first, that no actual comparisons can be made with safe skin doses because of the vast difference in size between the human and the canine head, and, secondly, because we believe external cross-fire radiation to be a comparatively safe procedure if the patient is carefully watched. In several instances nausea has necessitated intermissions in the applications. We have repeatedly given 3,000 to 5,000 mg. hour applications spread over a considerable area of the scalp with no bad results, and up to this point, at least, the only danger to be avoided, aside from nausea and collapse, which can be guarded against, is injury to the skin. Because of the frequency of nausea and possibility of collapse we prefer to proceed slowly with

smaller amounts of radium—100 to 150 mg.

The technique employed in the treatment of brain tumors must be based upon such important factors as the following:

1. The dose must be as safe a one as our clinical and experimental experience teaches us is possible, yet sufficient to accomplish the desired result.

2. Implantation is contraindicated when all the tumor is removed unless a large cavity persists and the radium can be packed in the center of the cavity.

3. If the growth is partly removed or not removed, the implantation dose must depend upon the size of the tumor to be treated and its nature, but with due regard to any possible destructive effect upon normal brain tissue. It may be safe to destroy normal tissue in some parts of the body, but in the brain the amount of destruction permissible is distinctly limited, not so much on account of loss of brain tissue as because certain serious constitutional effects may result.

4. For implantation, the size of the tumor must be known in order to reach all parts with some effect but at the same time protect normal tissue.

5. A knowledge of the pathological nature of the growth is essential.

6. Until we know from experience the relative amount of dosage required for the destruction of brain tumors as compared to that required to destroy tumors of the same nature and size elsewhere in the body, provided the tumor is not one peculiar to the brain, our dosage must be approximately the same for the one as for the other.

7. As the implantation dose necessary to destroy the growth will rarely if ever be a safe one, implantation alone will usually or always be insufficient and must be supplemented by cross-fire radiation from the outside, especially if we expect to control the actively growing peripheral cells.

8. Cross-fire radiation can be repeated with slightly reduced dosage over each area as soon as the skin reaction subsides.

To a certain extent, the treatment of each case is a law unto itself, but cases can be so grouped that a general technique can be prescribed for each group, as follows:

1. *Tumors accessible to the surgeon and presumably completely removed.* Implantation is contraindicated unless a large cavity persists and the radium can be packed in the center of the cavity. Otherwise, if any treatment is regarded as necessary, it must be carried out entirely by external cross-fire radiation. This may be accomplished by roentgen rays if so desired, but we prefer the use of radium, well screened and at comparatively close range. The exact technique is not of so much importance. The one we have employed is to map out the close-cropped scalp into squares of 1¼ inch dimensions. The radium is placed in a cubical lead box of the same internal dimensions, with the open end covered by 2 mm. aluminum and 5 ply thick rubber-dam filter. The radium is about 4 mm. from the skin surface when the box is applied to the scalp with a special holder. With 110 mg. of radium this box can be left over each square one hour, and a marked but safe reaction will be produced. Thirty to fifty squares are thus treated, depending upon the requirements. The external applications may be repeated with slightly reduced dose to each area as soon as the skin reaction subsides.

2. *Tumors accessible to the surgeon and partly removed.* The question of implantation depends upon the size of the growth remaining, its nature, and location favorable to the removal of the needles or capsules. If implantation is practiced, it should be as nearly as possible in the center of the tumor area and entirely within the tumor. The dose will depend upon the size of the tumor, but will usually be less than is required completely to destroy it. Implantation should be supplemented by external cross-fire radiation, or the latter alone may be all that is possible.

3. *Tumors accessible but not removed.* The same remarks apply.

4. *Tumors not localized or not found at operation.* Depend upon general external cross-fire radiation.

5. *Pituitary growths.* At the present time we do not advocate implantation into pituitary growths exposed by the transsphenoidal route. Radium, carefully screened, may be applied to the nasopharynx and this application supplemented

by external cross-fire radiation by roentgen rays or radium. The nasopharynx will easily stand 500 to 600 mg. hours. This form of postoperative treatment is well worth trying after sphenoidal decompression. In one instance hypopituitary symptoms developed after a single application.

Of all the thirty-two cases treated, those of most importance are the four treated in 1914. One had undoubted symptoms of brain tumor clinically and this was confirmed by *x*-ray examination, but the tumor could not be localized and almost the entire head was exposed to cross-fire radiation. After giving about as much treatment as we dared without apparent improvement, the parents refused permission for further applications. Soon afterwards the child improved and lived five years without further treatment. She died of influenza. The other three cases are still living.

One of these cases was operated upon in 1914 by Dr. Frazier, and had about seven-eighths of a gliosarcoma removed from the left cerebellar region. She was then treated by cross-fire *x*-ray over a period of three months and again by radium once a year subsequently. She came back with a recurrence in June, 1920, and could not walk alone. A 50 mg. capsule was implanted in the growth for eighteen hours, followed by rapid improvement of symptoms. In October there was an increase in the growth and cross-fire radium radiation was given, followed in a month by another implantation of 50 mg. for eighteen hours, followed again by decided improvement. In April, 1921, another cross-fire application was made. She still has an ataxia, but no headache and is undoubtedly better.

Another of the three cases was operated upon by Dr. Frazier in 1914 and a large tumor exposed in the cerebellar region, supposedly glioma, and 85 mg. of radium implanted in the inoperable growth for 17 hours (1,445 mg. hours). Subsequent cross-fire radium radiation was given in 1915, 1916, and 1917. The case was decidedly improved although some ataxia remains and he never recovered his sight. An exploratory operation this summer revealed a large cyst occupying the seat of the original tumor. The pathological report on a section of this cyst wall showed no evidence of tumor formation, only a process of "chronic irritation."

The remaining case was operated on by Dr. Frazier in 1913 and 1914 (two stages) but no tumor was found in the cerebellar region. The prominent symptoms were

TABLE

SUMMARY OF CASES TREATED

| *Year first treated* | *Number cases treated* | *Cases living 1921* | *Years living after first treatment* | *Dead* | *Operations—Cases still living* | | | | *Pathological report—Cases living* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Tumor removed* | *Tumor partially removed* | *Tumor not removed* | *Tumor presumptive* | *Glioma* | *Endothelioma* | *Sarcoma* | *Pituitary not determined* | *Not determined* |
| 1914 | 4* | 3* | 7 | 1* | .. | 1 | 1 | 1* | 1 | 0 | 1 | .. | 1 |
| 1915 | 4 | 0 | .. | 4 | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 1916 | 3 | 0 | .. | 3 | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 1917 | 4 | 2 | 4 | 2 | .. | .. | 1 | 1 | 1 | .. | .. | .. | 1 |
| 1918 | 4 | 3 | 3 | 1 | 2 | .. | .. | .. | ? | 1 | .. | .. | .. |
| 1919 | 1 | 1 | 2 | 0 | .. | 1 | .. | .. | .. | .. | .. | 1 | .. |
| 1920 | 10 | 7 | 1 | 3 | .. | 2 | 5 | 1 | 2 | 2 | .. | 3 | .. |
| 1921 | 2 | 2 | .. | 0 | .. | 2 | .. | .. | .. | 0 | 1 | .. | 1 |
| Totals | 32 | 18 | .. | 14 | 2 | 6 | 7 | 3 | 6 | 3 | 2 | 4 | 3 |

* One case treated a few months; further treatment refused; lived 5 years.

headache, vomiting, almost total blindness, and the patient could not walk without assistance. She was somewhat improved after operation. Radiation by cross-fire radium applications has been given a number of times. At the present time, she goes to school, can read easily and walks alone with only a slightly ataxic gait.

We believe that radiation had a decidedly beneficial effect upon all four of these cases and that the subsequent histories of many of the cases treated in later years will show similar results. We acknowledge the possibility of over-enthusiasm, but we feel sufficiently encouraged to advocate the treatment of a large number of cases by many individuals, and further animal experimentation, in an attempt to prove to the satisfaction of others that radiation is of distinct value and to improve the technique of the application.

We are now treating a case of endothelioma (pathological report) which originated apparently in the pituitary region and later grew down into the sphenoid sinuses and into the nasopharynx. The effect of treatment upon this tumor, if any, can be observed, and will be watched with much interest.

DISCUSSION

Dr. James T. Case. I would like to show some slides of a patient who in January, 1920, came to the Battle Creek Sanitarium almost totally blind. *X*-ray examination showed a very much enlarged sella. The roentgenogram of the sella and the graphic showing the visual field I will present on the screen. He was subjected to operation by Dr. B. N. Colver who removed, through the transnasal route, fragments of a tumor which proved to be adenoma. The patient's visual field was practically normal within two weeks; but as time went by his visual field gradually began to contract again. The surgeon realized that he had taken out only a small portion of the tumor. By May of this year the patient's visual field was again contracted as much as before the operation.

The question of using deeply penetrating *x*-rays came up, and we decided to subject this man to radiation with voltage of 180,000 and upwards. This decision was not reached, however, until the end of July by which time the visual fields were as shown in the slide before you. We accordingly treated him through five areas—rather small areas, the portals of entry being $4 \times 4$ cm. The line of attack was carefully calculated after studying the skull and the radiogram. Within one month the widening of the visual field was so pronounced as to be startling. We hope for a permanent improvement of the visual field in this man.

# THE TREATMENT OF PRIMARY CARCINOMA OF THE VAGINA WITH RADIUM*

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I AM presenting this paper for the purpose of calling the attention of radiologists to the treatment by radium of primary carcinoma of the vagina, and with the hope of stimulating more frequent reports of such cases giving the methods of treatment and the ultimate results obtained. I have found only three cases reported in the American literature.

Ward, in 1908, reported a case in which the disease had extended, and a rectovaginal fistula had formed two months after the application of the radium. Levin and Griffith both reported cases in 1914; their reports were made three months after the completion of the treatment, and both local and general improvement was marked.

Primary carcinoma of the vagina is comparatively rare. Williams states that less than 1 per cent of all cancers in women are of vaginal origin. The lesion usually occurs between the ages of thirty and forty. Williams reported the case of the youngest patient on record, a girl of seventeen. He believes that the often quoted cases of Guersant and of Johannovsky in which the patients were three and one-half years and nine years respectively, were of sarcoma and not of carcinoma. In our series of 21 cases, the youngest patient was twenty-eight. Three patients (14.28 per cent) were under thirty-five, the average age was 50.14 years.

Apparently trauma is not an etiologic factor in these cases, otherwise carcinoma would occur more frequently, since the vagina is subjected to many injuries from childbirth, prolapsus uteri, and the wearing of pessaries. Seventy-six and nineteen hundredths per cent of our patients had had children. None of them had prolapsus of the uterus.

All observers report that the growth occurs most frequently in the upper posterior portion of the vagina. In our series 42.8 per cent occurred on the posterior surface; 28.5 per cent on the anterior, and in 23.7 per cent there was involvement of most of the vaginal mucous membrane.

The course of the disease is very rapid. The average length of life following the first symptoms has been estimated sixteen and one-half months, the longest twenty-five to twenty-six months, and the shortest eight months. The rapid course and early glandular involvement are due to the free lymphatic supply of the vaginal mucous membrane.

Three groups of lymphatics drain into the pelvic glands from the vagina. A superior group arises from the upper third of the vagina and passes in front of the ureter, is joined by vessels from the cervix, and empties in the middle chain of the external iliac glands. The middle group comes from the middle third of the vagina and terminates in the hypogastric gland situated at the origin of the vaginal artery. The inferior group drains the lower third of the rectovaginal septum, travels along between the rectum and the sacro-recto-genital aponeurosis, and terminates in the gland of the promontory of the sacrum. The lymphatics of the vagina anastomose with those from the cervix, the vulva, and the rectum (Poirier, Cunéo and Delamere). This lymphatic supply explains the disappointing results in the surgical treatment of cancer in this location and also the subsequent glandular involvement when the local growth has been cured by radium. Metastasis to distant organs, however, is rare.

The symptoms of carcinoma of the vagina do not differ from those of carcinoma of the cervix. In our cases bloody discharge, leukorrhea, and in 52.63 per cent malodorous discharge, were noted. Pain

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is not an early symptom and occurred in only 57.14 per cent. It is described usually as a low backache, or as inguinal.

Of the 21 patients with primary carcinoma of the vagina treated at the Mayo Clinic from July, 1915, to January, 1921, information concerning 14 has been obtained recently in answer to questionnaires. Seven of the 14 are living. One has lived three years and nine months, one two years and nine months, one two years and one month, one one year and two months, two six months, and one five months. Of those who died, one died two years and four months after treatment, one died one year and three months after treatment, one died one year after treatment, two died eleven months after treatment, and two died seven months after treatment.

### SUMMARY OF CASE HISTORIES OF THE SEVEN LIVING PATIENTS

CASE I. Mrs. J. A., aged fifty-eight, had passed the menopause eight years before. For two years she had had a watery irritating vaginal discharge, recently tinged with blood, some pelvic discomfort and bearing-down pain. Examination showed a small papular roughness of the vaginal mucous membrane, slightly indurated and bleeding, on the left anterior wall of the vagina just within the introitus. No glands were palpable. Fifty mg. of radium salt were applied for six hours, directly against the ulcerated area. A specimen of the lesion removed one month later was reported to be inflammatory. The patient reported three years and nine months after treatment. She had recently lost 35 pounds in weight, but had no pelvic pain nor vaginal discharge.

CASE II. Mrs. H. G. F., aged eighty. Three months before the patient had noticed a growth in the posterior vulva, and occasional bleeding. A cauliflower growth, superficial, with very little induration, involved the posterior vaginal orifice and extended onto the perineum. The inguinal glands were not palpable. Two applications were made of the 25 mg. plaque for fourteen hours each, with 2 mm. brass and one-half inch gauze screening, and 2,000 mg. hours over the inguinal glands. Two months later 50 mg. radium salt were given for ten hours and twenty hours respectively over the posterior vulva and perineum. The patient reported two years and nine months later. Her general health was good and there was no evidence of local trouble and no discharge.

CASE III. Mrs. J. J. B., aged fifty, menstruated irregularly, and had had pain in the back and hips, and occasionally intermenstrual bleeding for two or three months. She had lost slightly in weight. The posterior vaginal wall was indurated, nodular and with some ulceration extending to within half an inch of the introitus. The cervix was atrophied. No glands were palpated. Four vaginal treatments of 50 mg. hours of radium salt for fourteen hours, screening with one-half inch gauze and 2 mm. brass, and posteriorly by 2 mm. lead, and two rectal applications of 50 mg. hours for two hours, at intervals of from three to four days were given. *X*-ray exposures were made over the abdomen and back. The patient returned two months later. She had gained in weight and strength, and was free from pain and discharge. Examination showed two indurated and nodular areas, one in the posterior vault of the vagina and one just within the introitus. There was no evidence of glandular involvement. Two applications of radium to the vagina, two to the rectum, and *x*-ray treatment were given. The patient returned five months later still in good health and free from discharge. The vaginal mucous membrane was smooth, with slight induration in the anterior vaginal wall. The left inguinal gland measured 2 cm. by 1.5 cm. Another course of treatment was given as before, and also radium exposure over the inguinal glands. The patient was last seen in August, 1920. She complained of pain in the back and hips and down the right leg, and recently occasional slight amounts of dark blood passed by rectum; defecation was not painful. She had the same clear odorless vaginal discharge; she had not lost weight. The vaginal mucous membrane was smooth, the vagina slightly contracted. The left inguinal glands were enlarged and a few small glands were palpable by rectal examination. The rectal mucous

membrane was smooth. The patient was given one vaginal treatment of 700 mg. hours (50 mg. radium salt for fourteen hours), and 2,752 mg. hours over the left inguinal region. Two years and one month after the first examination the patient reported a poor general condition.

CASE IV. Mrs. W. M. S., aged sixty-two, had passed the menopause ten years before. For five months she had had a slight blood-streaked vaginal discharge, recently with a slight odor. She had lost but little in weight. An indurated nodular growth was found involving the vault of the vagina. Three cervical applications of 50 mg. radium salt for fourteen hours were given, one vaginal application of 68 mg. for ten hours and two rectal applications of 100 mg. hours each. Three months later three vaginal treatments of 700 mg. hours each and two rectal treatments of 200 mg. hours each were given. Six months later two vaginal treatments of 700 mg. hours each were given. The patient returned in six months, one year and two months after the first treatment, reporting a gain in weight and in strength, and practically no discharge. She was doing her own housework. The vaginal mucous membrane was found to be thickened and there was a small soft nodule on the posterior wall of the vagina. The vagina was shortened and the cervix flush with the vault. The left broad ligament was slightly thickened. A proctoscopic examination showed a slight ulcerated area on the anterior rectal wall. The patient was given *x*-ray treatment to the abdomen and back, but no more radium treatment.

CASE V. Mrs. C. E. R., aged thirty-six, had menstruated regularly. For four months she had noted an occasional bloody discharge and pain in the vagina radiating into the back. Her general health was good. An epithelioma 5 cm. in diameter was found on the posterior wall of the vagina. The cervix was free from involvement. No glands were palpable and the rectal examination was negative. The pathologist reported epithelioma, grade 3. Five exposures of 50 mg. radium salt for fourteen hours each, at from three to five day intervals, and *x*-ray treatment over the abdomen and back were given. The patient returned six months later. She had gained in weight, had very slight, if any, vaginal discharge, and no pain. She had had two menstrual periods since treatment. The vaginal mucous membrane was smooth and not indurated; the cervix was free from involvement, and the uterus moveable. Examination of the rectum was negative. The patient was given *x*-ray treatments over the abdomen and back, but no further radium. She was advised to report in four months.

CASE VI. Mrs. A. F. C., aged sixty-nine, had passed the menopause twenty-two years before. For three months she had had a bloody vaginal discharge, and had lost slightly in weight. On the posterior wall of the vagina was a proliferating tumor about 2.5 cm. long. No glands were palpable. The pathologist reported epithelioma, grade 4. Three vaginal exposures of 50 mg. for fourteen hours, and *x*-ray over the abdomen and back were given. A physician who examined her recently found no evidence of malignancy and reported her general health good six months after the treatment.

CASE VII. Mrs. C. R. S., aged sixty-three, had passed the menopause seven years before. For six weeks she had noticed mucous vaginal discharge, but no bleeding. A proliferating growth 2 cm. to 3 cm. in diameter was found on the posterior wall of the vagina; it was superficial, and no glands were palpable. The pathologist reported squamous cell epithelioma, grade 3. The patient was given one application of 50 mg. radium salt for fourteen hours in a wax mould, and two days later emanation needles were buried to approximate 518 mc. hours. Four days later the growth was excised with a portion of the posterior vaginal wall. Twelve days later two more treatments of 50 mg. for fourteen hours were applied. The patient was recently examined five months after the first treatment, by a physician who reported the local and general condition to be good.

### SUMMARY OF CASE HISTORIES OF THE SEVEN PATIENTS NOW DEAD

CASE VIII. Mrs. M. O., aged forty-three, had fallen astride a bathtub five

months before, and since then had bled irregularly and had noticed a swelling in the vagina. Examination revealed a cauliflower growth involving the anterior and the right vaginal wall. The uterus was movable. A total of 1,750 mg. hours radium into the vagina in three treatments, and two rectal treatments of 100 mg. hours each were given. The patient returned three months later stating that all discharge had ceased two weeks after the treatment, but a small new growth had appeared just within the vulva. Two vaginal treatments of 700 mg. hours each were given. When she reported one month later the vaginal mucous membrane was smooth and there were no adhesions. No induration was detected by rectal examination. Two months later there was found a small ulcerated area on the anterior vaginal wall and this was exposed to 600 mg. hours radium salt. The patient was not seen again until one year and three months after the first examination and eight months after the last radium treatment. There was no evidence of malignancy at this time and a diagnosis was made of a clinical cure. About six months later, however, she developed retroperitoneal tumors and died apparently of abdominal carcinoma, two years and four months after the first treatment.

Case IX. Mrs. A. H. P., aged forty-one, had had a pus-like discharge for seven months, and soreness around the vulva at intervals. Examination showed an ulcerating growth posterior to the urethra, about 3 cm. in size. She was given 600 mg. hours over the growth, and returned in two months. At this time there was merely an area of induration at the site of the growth, and induration of the labia, but the inguinal glands on both sides were enlarged. She was again given two treatments of 500 mg. hours each and *x*-ray treatment over the glands. Three months later when she returned for examination there was rather a deep ulceration but it did not involve the urethra and the glands were still large and tender. Another series of 1,000 mg. hours radium salt was given as before, and *x*-ray treatment. The patient died one year and three months after the first treatment.

Case X. Miss A. K., aged forty-four, gave a history of intermenstrual bleeding for from seven to eight months, and examination showed a carcinoma involving nearly all of the vaginal mucous membrane, associated with thickening in the broad ligaments. She was given three series of 20,000 and 21,000 and 22,000 mg. hours of radium salt respectively at three month intervals. There was local improvement but metastatic extension to the iliac glands, and the patient died one year after the first treatment.

Case XI. Mrs. C. F., aged twenty-nine, had a large proliferating and ulcerating mass involving most of the posterior vaginal wall. This patient received 2,100 mg. hours by vagina (50 mg. for fourteen hours each for three applications) and 200 mg. hours by rectum. She improved after the first treatment, and three months later received a second series similar to the first. In two months, and again in three months she had severe hemorrhages, and died eleven months after the first treatment.

Case XII. Mrs. R. McT., aged fifty-eight, gave a history of vaginal bleeding for one year. She had a polypoid mass 2.5 cm. long just within the orifice of the vagina, on the right and posterior surface, and nodules on both lateral walls; the inguinal glands were enlarged. She was given 1,200 mg. hours into the vagina. Improvement following treatment was only temporary and she died eleven months later.

Case XIII. Miss M. Van O., aged twenty-eight, had had a watery discharge from the vagina for five months and pain in that region for three months. The entire lateral and posterior walls of the vagina were involved. The inguinal glands were not palpated. Three vaginal treatments of 700 mg. hours each and two rectal treatments 100 mg. hours each, were given. The patient returned three months later. She had had three hemorrhages two weeks before. The entire mucous membrane of the vagina was nodular and bled easily. An examination by rectum revealed marked thickening in both broad ligaments. Another series of treatments was given consisting of 728

mg. hours into the cervix, 300 mg. hours into the rectum and 1,400 mg. hours into the vagina. The patient died in three months, seven months after the first treatment.

CASE XIV. Mrs. E. L., aged thirty-two, had had a watery discharge of foul odor from the vagina for two months and pain for one month. Her menstrual periods had been regular. Examination revealed a large fungating growth on the left posterior surface of the vagina. The posterior lip of the cervix was granular, the inguinal glands were not palpated. Three vaginal treatments were given of 50 mg. radium salt for fourteen hours each and two rectal treatments of 50 mg. radium salt for two hours each. The patient died seven months later.

All the patients in this group were given *x*-ray treatments over the abdomen and back in conjunction with the local radium applications. As the technique of radium treatment improves the results will improve, particularly in the recent cases in which the emanation needles are buried in the growth, or in which much larger doses of radium salt are given. The increasing efficiency of the *x*-ray treatment is also an important factor. In our cases the local condition has been comparatively successfully controlled, but extension into the glands has not been prevented. We have no doubt been over-apprehensive of the development of vesicovaginal fistulas, and might have given heavier doses. Vesicovaginal fistulas and rectovaginal fistulas occurred in one case, one year after the beginning of the application of radium, following the third series of treatments.

## SUMMARY

1. Primary carcinoma of the vagina is comparatively rare.

2. The symptoms are similar to those of carcinoma of the cervix.

3. The disease extends early to the iliac glands; it rarely extends to other organs.

4. Radium and *x*-ray treatments offer better chances for a cure than surgery, and as the technique improves a larger number of permanent cures should be effected.

5. Better results are obtained and there is less danger of formation of fistula if the initial treatment by radium is heavy and not repeated, *x*-ray exposures to abdomen and back being, however, continued.

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# A NEW TYPE OF APPLICATOR FOR USE WITH RADIUM EMANATION*

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FOR a considerable time we have recognized that certain types of lesions could be treated much more easily and more accurately if it were possible actually to hold the radium in place by hand while the treatment was being given.

To meet this demand the following simple method has been devised, and after a trial of several months has proven of inestimable value in our work. It is offered for the benefit of those who use radium emanation and are thereby permitted to have a varying supply of applicators with varying amounts of radioactive substance in them.

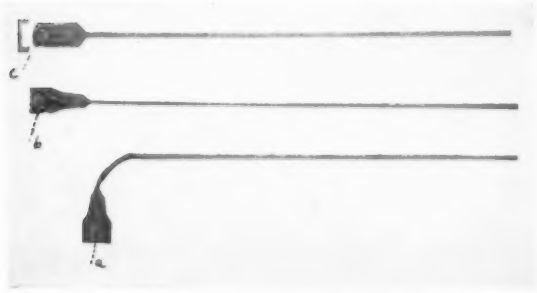

FIG. 1. (*a*) Shows bulb of radium emanation in curved container for larynx or other similar use. (*b*) Bulb in straight applicator. (*c*) Brass filter which may be placed over emanation bulb.

The entire output of emanation for twenty-four hours—about 600 mc.—is collected in a small, thin glass bulb 5 mm. in diameter (Fig. 1 A). The size and shape of this may be varied to suit individual needs.

This bulb is then sealed with paraffin in the end of a steel cone just large enough to receive it and permit of complete inclusion (Fig. 1 B). The steel cone has attached at its apex a pliable metal rod about 45 cm. in length which permits the operator to keep a reasonable distance from the emanation. The pliable material permits bending to facilitate applications in various locations. It will be seen that the bulb of radium emanation occupies the same position in the cone that a clapper does in a bell. At the base of the cone it is exposed and unfiltered, while in all other directions it is filtered by the steel jacket.

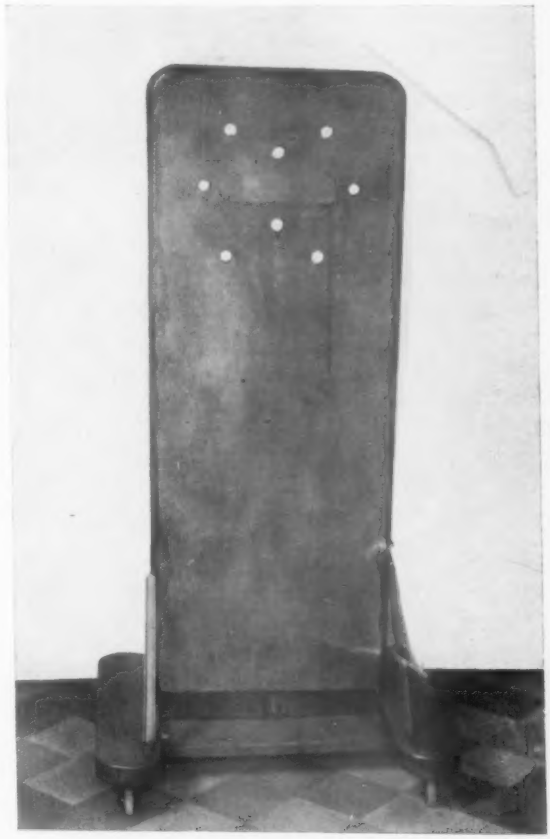

FIG. 2. Lead-lined board to protect operator.

In order to lend further filtration for

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certain cases another cone made of 2 mm. of brass with a 1 mm. brass cap to fit over the base of the cone has been constructed (Fig. 1 C).

While the distance afforded by the long metal handle is considerable protection to the operator, it is not sufficient for all radium for their treatment and a dangerous amount of exposure on the part of the operator.

Many of these are very superficial and a centimeter or less in diameter. In the treatment of such lesions this bulb has proved very valuable. It can be held in

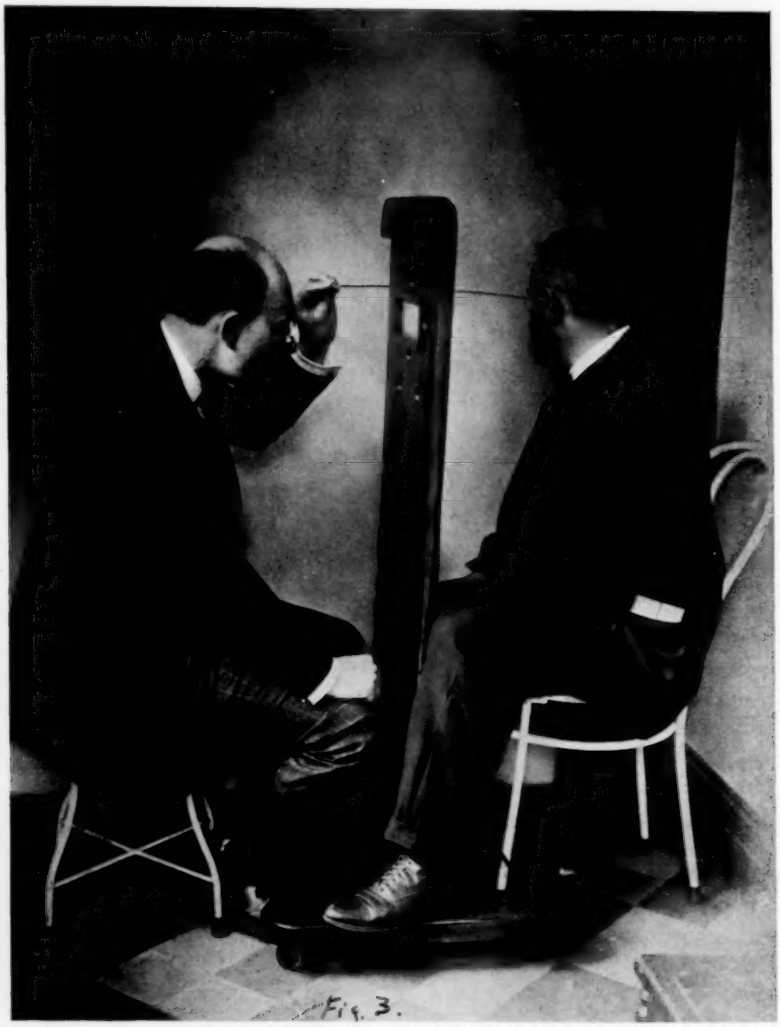


FIG. 3. Treating skin lesion.

practical purposes. To add to the safety there has been constructed a screen lined by 6 mm. of lead, with a glass window for observation, and perforations at various levels to permit passage of the applicator handle (Fig. 2).

The very large number of malignant skin lesions, usually basal cell epitheliomas, require the use of considerable filtered

place readily for the short period necessary (Fig. 3). An exposure of two minutes with 600 mc. of emanation is sufficient to clear up entirely a rodent ulcer 8 to 10 mm. in diameter. Since the radiation is from a flattened spherical surface, it is better adapted to these small lesions than a tube of radium which gives an oval field of radiation. Being unfiltered, both beta and

gamma radiation is utilized, resulting in a saving of radioactivity, and, since the radiation is softer, the reaction is not so deep, and healing is much more prompt.

We have found it advantageous to accumulate these small lesions for a fixed

FIG. 4. Treating lesion in larynx.

treatment period once in three weeks. Then with a strong, freshly collected bulb of emanation, as many as 40 or 50 cases may be disposed of in an afternoon. This relieves congestion in the service, and saves radium, time and exposure on the part of the operator.

When not in use in this manner the bulb may be put in a metal sphere or tube and used elsewhere as any other radium emanation tube or applicator.

We have found this method of special value in treating lesions in delicate locations. About the edges of the eyelids, at the inner canthus, or on the conjunctiva, where accuracy of application is the all-important feature, it has facilitated our work very materially. One case of epithelioma of the cornea, a lesion 10 × 12 mm. in size, has been entirely cleared up by an exposure of 648 mc. minutes—162 mc. of emanation applied over one area for two minutes and over two other areas for one minute each.

The filtered bulb shown in Figure 1c was constructed primarily for the treatment of a pigmented sarcoma of the iris where deeper penetration was desired and precision in application was of utmost importance.

For the treatment of papillomas of the larynx or unilateral superficial laryngeal carcinoma, it affords a means of very accurate approximation of the radium while it also protects to a considerable extent the opposite normal cord. Figure 4 shows such an application being made by the indirect method.

We have also utilized this method in the radiation of leukoplakia patches of the buccal and lingual mucosa where a very superficial effect is desired.

# A COMPARISON OF RADIATION DOSAGES ATTAINABLE BY USE OF RADIUM ON AND WITHIN TUMORS*

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THE past several years have witnessed considerable change and improvement in the technique of radiotherapy with corresponding indications of better results following treatment in some conditions where the prognosis formerly was very poor. We have also heard a great deal about the experiments and the newer *x*-ray technique which the Germans have devised.

One of the most interesting points brought out by the experiments of Friedrich and Kroenig, as given in their text on the "Physical and Biological Bases of Radiotherapy," was the observation that the *x*-ray dose at the depth of 10 cm. in tissues is three to four times greater than the dose which is to be expected if the calculation takes into account only the effects of absorption and distance. This greater dose is accounted for as due to secondary radiation from the tissue and scattered primary radiation.

The same sort of a phenomenon has been observed by Friedrich and Glasser[1] for the gamma rays of the radioactive substance, save that here at 10 cm. distance through tissue, the increase is only in the order of 60 per cent instead of 200 to 300 per cent as was the case with the *x*-ray dose.

Interesting as these results are and important as it is that they be extended, it nevertheless remains a fact that the clinical results must measure the value of any method and any technique.

The nature of things requires that deep *x*-ray treatments be given by firing massive doses of the rays through a portal, usually a normal skin area, towards the point to be influenced; and the limiting factor in *x*-ray dosage has usually been the limit of tolerance of the skin. The use of harder rays has improved results, but the use of massive doses of *x*-ray through normal tissues gives rise to bad systemic effects, and later there is the great likelihood of development of troublesome fibrous tissue.

Compared with the *x*-ray, radium by reason of its compactness offers more, since the radium applicator may be brought into contact with the foreign growth even when this is deeply seated.

In the first development of radium technique most of the massive doses were applied by bringing the radium in contact with the exterior of the growth, and depending on the penetration of the rays and exterior cross fire to produce a sufficient effect on the most inaccessible outlying cells.

Radium emanation has been used implanted in tumors since Joly and Stevenson[2] in Dublin in 1914 published the report on using tiny emanation tubes in hypodermic needles, which were thrust through the growth. Duane suggested the implantation of the bare glass emanation tubes; and within the last few years this method has been much used following the large use made of the method and the encouraging reports made on its employment by the late Dr. Janeway and his associates at the Memorial Hospital in New York.

As an approximation of the radium emanation, metal needles containing radium salt have also been employed for insertion into growths. The value of the radium salt makes it necessary to protect the material adequately; hence metal radium needles have a bulk which is even greater than would be necessary if the needle were simply to serve as a container that did not have to withstand considerable mechanical forces, not to mention the abuse which is frequently put upon such forms of applicators in forcing them into dense, fibrous growths.

Reports from those using such metal radium needles would indicate that they

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are satisfactory as the equivalent of the emanation seeds in most instances; therefore the small radium-user need not be deprived of the advantages which the emanation-user enjoys.

The immediate problem in the radiotherapeutic treatment of a localized malignant growth is to secure an adequate or lethal dose of rays in the most outlying cells, since a failure to accomplish this result leaves the patient in much the same predicament that results when the surgeon cannot excise all of the malignancy.

The intensity of the rays from a small source varies inversely as the square of the distance from the source, when absorption is neglected. Since gamma rays of radium are so penetrating that the fall in their intensity due to absorption in tissues is markedly offset by the effect of scattered and secondary rays in the tissue, absorption may then be neglected. If the distance from the radium to the most outlying cells is set as 1, then the intensity of the rays is $\frac{1}{(1)^2} = 1$ on those cells. If now by insertion into the tumor mass the distance between the radium and the most outlying cells is reduced to ½, the intensity of the rays becomes $\frac{1}{(\frac{1}{2})^2} = 4$.

It follows then that with the same amount of radium inserted for the same length of time, the ray dose applied to the most outlying cells will be increased fourfold.

It is the utilization of this principle by multiplying the number of points from which the rays emerge, which gives the possibility of most nearly approximating homogeneous radiation, and of securing the most intense effects of the radiation within the tumor and thereby avoiding the great waste of rays that results when external cross fire is used, together with the possible undesirable effects of these wasted rays in normal tissues adjacent to the neoplasm. A little thought will show that upwards of three fourths of the rays from a tube laid over a growth will fail to strike the growth, and if there are normal tissues lying near the radium applicator, as for example the mucosa, etc., in the mouth, then there is every likelihood of a bad burn in these tissues by reason of the intense action of the wasted radiation.

The future developments in radium technique which promise most, are those which will seek to place the radioactive substance throughout the mass of neoplastic tissues; and it is only in such manner that radiotherapy combined with other suitable methods can hope to control or destroy some of the malignant growths, such as cancer in the bladder, prostate, stomach, etc., where at present the prognosis is far from favorable.

Another point which I would like to mention before closing, is that brought out in a paper by Friedrich and Bender[3] regarding the possibility of enhancing the action of *x*- and gamma-rays by the action of radiators, such, for example, as implanted metal needles, injected colloidal metals, etc., or injected salts like potassium iodide. The opinion has been generally held that the use of such means would result in the absorption of more rays, and, rather illogically, it has seemed to me, more action by the rays in the tissue cells. The results of Friedrich and Bender indicate that not only is the intensity of the rays not increased, but in most of their experiments, due to the radiator cutting out scattered radiation, the radiation intensity is actually less in the tissue than when no radiator is used. The clinical results, where various injections, etc., have been made in an effort to enhance the absorption of the rays and so increase their action on the tissues, have so far not indicated any advantages for this method, and, in view of Friedrich and Bender's experimental results, the promise of this method does not seem great.

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# THE EFFICIENCY OF THE BUCKY-DIAPHRAGM PRINCIPLE*

BY R. B. WILSEY

Communication No. 129 from the
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IN the course of a general study of the scattering of *x*-rays under the conditions of deep roentgenography, a considerable amount of data has been secured showing the large influence of scattered radiation upon roentgenographic quality. In roentgenographing through water layers varying in depth from 4 to 10 inches, the scattered radiation affecting the film was found to be from two and a half to eleven times as intense as the primary radiation.[1] The relative intensity of scattered and primary radiation was but little affected by the tube voltage, the use of filters between scattering material and the film, or the use of intensifying screens.[2]

The scattered radiation reaching the film apparently differs so little in quality from the primary radiation that the only effective method of reducing its relative intensity is by means of diaphragms, which either limit the scattered radiation by restricting the volume of material rayed, or, as in the case of the Bucky-diaphragm principle, prevent the scattered radiation once formed from reaching the film. Experiments by the first-named method, that of using cones or diaphragms between the *x*-ray tube and the scattering material, have shown that a greater improvement is possible in contrast and definition by a reduction of scattered radiation than by any other form of roentgenographic technique. Better contrast and definition mean more detail, and therefore more information upon which to base a diagnosis. Evidently a satisfactory solution of the problem of scattered radiation will give a greater improvement in roentgenographic quality than any other technical advance in prospect at the present time.

The reduction of the intensity of scattered radiation by limiting the volume of the material rayed has only a limited application in practice on account of the small size of the roentgenographs possible by this method. The Bucky diaphragm is free from this objection, and the modification developed by Dr. Potter[3] also makes it possible to avoid the shadows of the diaphragm grids, a fault which made the original form of the Bucky diaphragm impractical. The Potter-Bucky diaphragm appears to be the only method now practicable for removing scattered radiation over the whole area of a large roentgenograph. It was therefore considered highly desirable to investigate by quantitative methods the efficiency and possibilities of this apparatus and the effects of various factors entering into the design of the diaphragm grid.

In this study two types of experiments were carried out, one consisting of measurements of the relative intensities of diffuse and focal radiation and the other experiments upon definition. The term diffuse radiation is used here to include both scattered radiation and primary radiation from other parts of the tube than the focal spot, while focal radiation refers to primary radiation coming from the focal spot.

## THE EXPERIMENTAL METHOD

The Potter-Bucky diaphragm consists essentially of a series of metal strips whose horizontal directions are parallel and whose planes (projected) pass through the focal spot of the tube. A suitable mechanism moves the grid during the exposure in such a way as to prevent the shadows of the lead strips from showing in the roentgenograph. The space between each pair of metal strips forms a slit through which may pass the primary focal rays and scattered rays within a limited angle; scattered rays coming from beyond this angle are largely absorbed by the metal strips. The conditions in each slit are duplicated in every other; hence if the effectiveness of a single slit in reducing

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scattered radiation be determined, the result holds for the whole diaphragm. The advantage of using a single slit in this investigation is that its dimensions can be varied easily as desired, whereas a complete grid would be rather troublesome to alter in studying the effects of any changes in its form and dimensions.

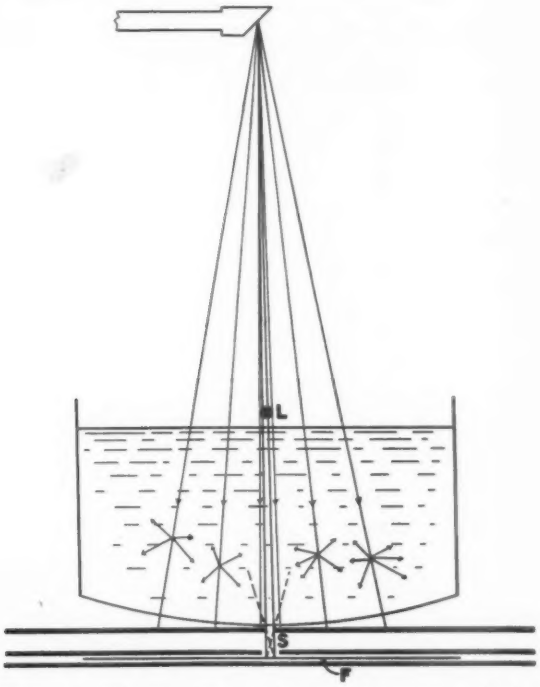


FIG. 1 A. Diagram illustrating experimental method; a disc of lead, L, is suspended over the tank of water and intercepts a small portion of the primary rays falling upon the film F through the slit S. The dotted lines show the angle within which scattered radiation may fall upon the film.

The effective depth of such a single slit is the distance from its upper edge to the photographic surface as illustrated in Figure 1A. Such is not the case in a complete Bucky grid, as shown in Figure 1B, where the effective depth of the slit is the depth of the lead strips. If in the latter case the film were brought up into contact with the lower edge of the grid, the effectiveness of the grid in removing scattered radiation would not be changed; the conditions in each slit would then be independent of those of every other slit and would be identical with the single slit arrangement as used in the present investigation.

When the film itself is at the same level as the bottom of the slit, the definition will be slightly better than in the case where the film is below this level. Consequently in definition experiments with the single slit arrangement the results will be slightly more favorable than would be obtained with a complete grid as operated in practical roentgenography, assuming equal slit width and slit depth

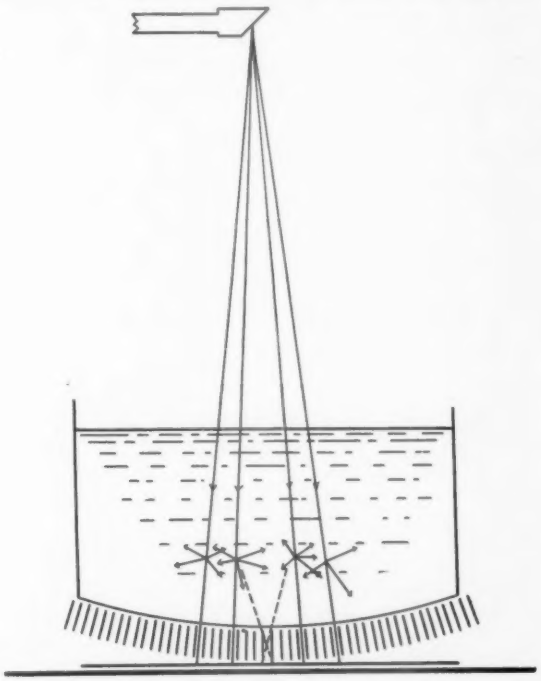

FIG. 1 B. Illustrating a complete Potter-Bucky grid for comparison with the single slit method of Fig. 1 A.

in the two cases. It will be apparent later that the definition obtained with a single slit should be identical with that given by a complete grid, provided that in these two cases there is the same distance between the scattering material and the film, and the same *ratio* of slit width to slit depth.

Water contained in an aluminum tank 12 inches square was used as the scattering material. The bottom of the tank was of $\frac{1}{32}$ inch aluminum and was curved in the form of a cylindrical surface having a radius of curvature of 25 inches. The lead slit was formed by the beveled edges of two lead plates, each $\frac{1}{8}$ inch thick and mounted on flat steel plates of the same thickness. The slit was 14 inches long and was located centrally under the tank. When necessary, another pair of lead plates was situated immediately over the

film holder to limit the area of film that could be exposed at one time. A small disk of lead, L, one quarter inch in diameter and 1/16 inch thick was placed edge upward over the surface of the water in line with the slit and the focal spot (Fig. 1A). This intercepted a small portion of the primary rays and allowed only diffuse radiation to fall within its shadow on the film. Three such disks were suspended over the water at such distances that their shadows on the film were about two inches

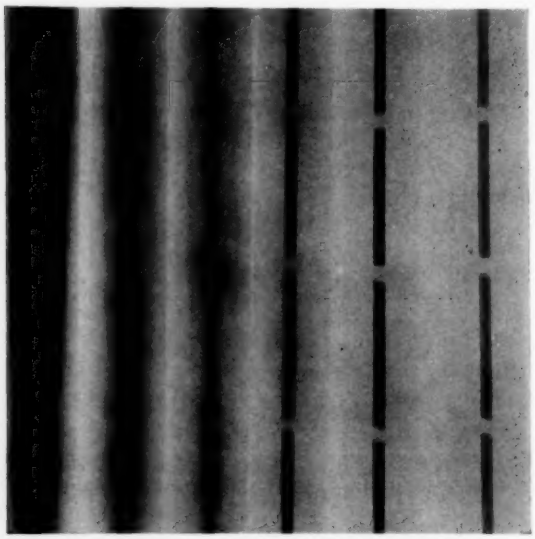

FIG. 2. Reproduction of a film obtained for determination of ratio of diffuse to total radiation.

apart; the *x*-ray image of each slit therefore contained three small areas affected by diffuse radiation only, while all other portions of the image received both the diffuse and the focal radiation. A series of varying exposures through the slit were made upon an 8 × 10 sheet of duplitized film. Figure 2 shows a reproduction of such a film. A microphotometer was used to measure the densities on the film, and curves were plotted of the photometer reading against the exposure, both for the total radiation and for the purely diffuse radiation. From these curves were read the exposures required to produce equal densities by the diffuse and by the total radiation. The reciprocal of the ratio of these exposures gave the ratio of the intensities of the two radiations. This ratio was determined for four or five density values on the curves for each film, and the final value for D/T, the ratio of the diffuse to the total radiation, was taken as the mean from four or more films. The details of this photographic method of evaluating relative *x*-ray intensities are the same as those described more fully in a previous paper.[1]

All the determinations of the ratio D/T were made using a 6 inch depth of water, measured in the center or deepest portion of the tank. The target-slit distance was 25 inches, the tube voltage 60 kv. (sphere gap calibration), and the tube current 4 ma. A radiator type Coolidge tube was used throughout the experiments. The films were developed in a tank of Elon-hydroquinone developer, and were kept in constant irregular motion to insure uniformity of development over the whole area of the film.

## THE EFFECT OF THE BUCKY DIAPHRAGM UPON THE INTENSITIES OF SCATTERED RADIATION

The first experiments were performed to determine the effect of the distance between scattering material and slit upon the proportion of scattered radiation reaching the film. It has been claimed that theoretically the Bucky diaphragm principle should show a maximum of efficiency in removing scattered radiation when the subject roentenographed is at some distance from the grid.[4]

To test this conclusion, the ratio of diffuse to total radiation was measured with the tank of water at various distances up to one inch from the slit. The slit was 0.13 inch wide and 0.65 inch deep, giving a ratio of width to depth of 0.2. The values of D/T obtained at various distances between tank and slit are given in Table I.

TABLE I

EFFECT OF DISTANCE BETWEEN SCATTERING MATERIAL AND SLIT UPON PROPORTION OF DIFFUSE RADIATION REACHING THE FILM. SLIT WIDTH 0.13 INCH; DEPTH 0.65 INCH

| *Distance between Tank and Slit in Inches* | *Ratio Diffuse to Total Radiation* |
|---|---|
| | *D/T* |
| 0 | 0.40 |
| 0.25 | 0.39 |
| 0.50 | 0.40 |
| 0.78 | 0.41 |
| 1.06 | 0.42 |

The variations in D/T are seen to be quite small, negligible for practical purposes, and are of the same order of magnitude as the experimental errors. These data indicate no particular choice for the distance between slit and scattering material; for the subsequent experiments a distance of $\frac{1}{16}$ inch was arbitrarily determined upon for the distance between the slit and the bottom of the tank.

The next experiments were carried out to determine the effects of slit width and slit depth upon the ratio of diffuse to total radiation. Three depths of slit were used, 0.37 inch, 0.65 inch, and 1.00 inch, and the slit widths varied from 0.044 to 0.43 inch. The values of D/T for the various conditions are recorded in the fourth column of Table II. Column 5 of this table gives the values of D/F, the ratio of diffuse to focal

TABLE II

| *Width of Slit, Ws* | *Depth of Slit, Ds* | *Ratio of Width to Depth of Slit Ws/Ds* | *Ratio of Diffuse to Total Radiation D/T* | *Ratio of Diffuse to Focal Radiation D/F* |
|---|---|---|---|---|
| 0.044 | .... | 0.119 | 0.29 | 0.41 |
| 0.085 | 0.37 | 0.230 | 0.43 | 0.76 |
| 0.130 | .... | 0.351 | 0.52 | 1.08 |
| 0.043 | .... | 0.066 | 0.18 | 0.22 |
| 0.085 | .... | 0.131 | 0.32 | 0.47 |
| 0.130 | 0.65 | 0.200 | 0.40 | 0.67 |
| 0.172 | .... | 0.264 | 0.45 | 0.82 |
| 0.213 | .... | 0.328 | 0.52 | 1.08 |
| 0.298 | .... | 0.458 | 0.55 | 1.22 |
| 0.085 | .... | 0.085 | 0.22 | 0.28 |
| 0.130 | .... | 0.130 | 0.28 | 0.39 |
| 0.213 | 1.00 | 0.213 | 0.43 | 0.75 |
| 0.298 | .... | 0.298 | 0.46 | 0.85 |
| 0.346 | .... | 0.346 | 0.51 | 1.04 |
| 0.432 | .... | 0.432 | 0.55 | 1.22 |

In Figure 3 the values of D/T are plotted against Ws and in Figure 4 D/F is plotted

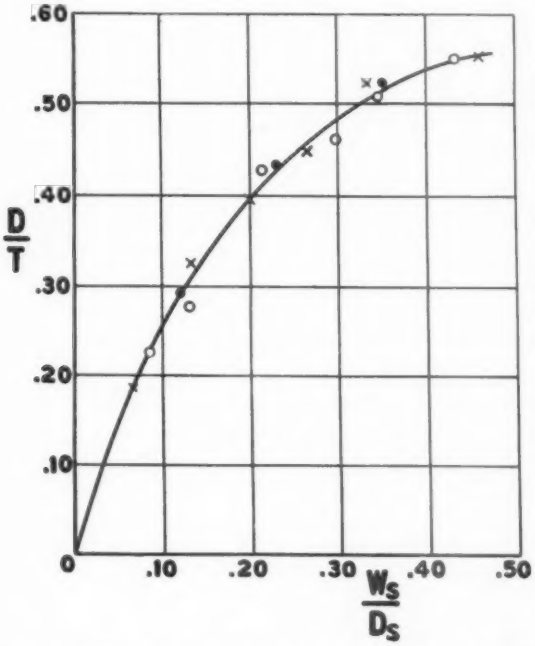


FIG. 3. Curve showing ratio of diffuse to total radiation as a function of the ratio of slit width to slit depth.

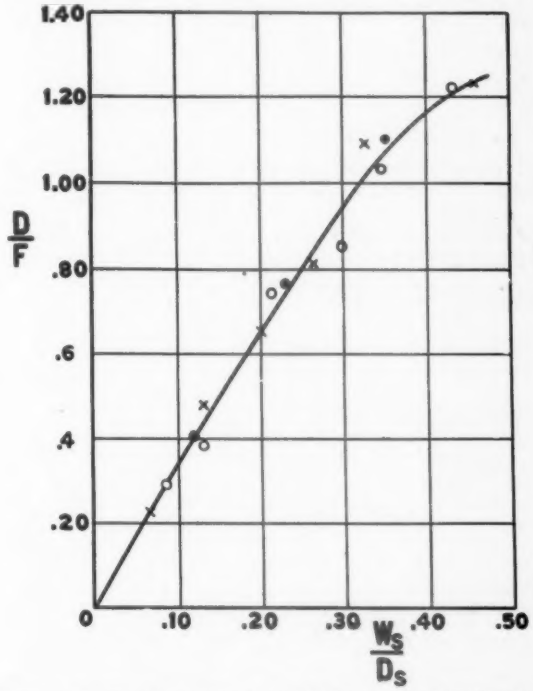


FIG. 4. Curve showing ratio of diffuse to focal radiation as a function of the ratio of slit width to slit depth.

radiation, computed from the values of D/T by the relation

$$\frac{D}{F} = \frac{D/T}{1 - D/T}$$

With no diaphragm or slit limiting the scattered radiation, the value of D/T was found to be 0.83 and the value of D/F, 4.9.

against Ws/Ds. The solid circles represent the values obtained with a slit depth of 0.37 inch, the crosses are for the slit depth of 0.65 inch and the hollow circles for the slit depth of 1.00 inch. It will be noted that the points for all these slit depths follow the same curve; in other words, the intensity of the scattered radiation is determined

by the ratio of slit width to slit depth but does not depend upon the actual size of the slit.

The curve in Figure 4 is nearly a straight line over most of its length, showing that the intensity of the diffuse radiation over a considerable range is practically proportional to Ws/Ds, that is, it is directly proportional to the slit width and inversely proportional to the slit depth.

Figure 5 shows the exposure factor plotted as a function of the ratio of slit

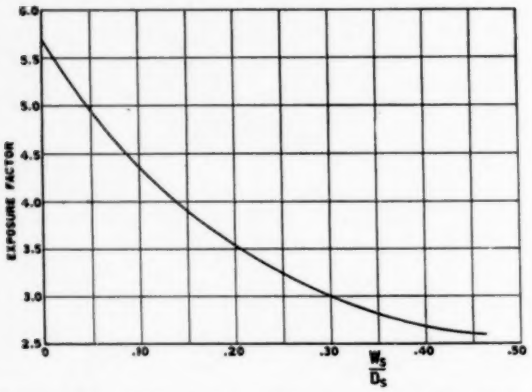


FIG. 5. Curve showing exposure factor as a function of the ratio of slit width to slit depth.

width to slit depth. The exposure factor is the number by which the normal exposure must be multiplied to obtain the proper exposure when the diaphragm removes some of the scattered radiation. The method of computing the exposure factor has been previously described.[1]

The *efficiency* of the Bucky diaphragm is defined as the fraction of the diffuse radiation which has been removed, as measured by the photographic surface. A diaphragm that removed all the diffuse radiation would be 100 per cent efficient. In roentgenographing through six inches of water with nothing to reduce the intensity of the diffuse radiation, the diffuse radiation is 4.9 times as intense as the focal radiation. If a diaphragm reduces the diffuse radiation to an intensity 0.49 times that of the focal radiation, whose intensity has not been changed thereby, then the diffuse radiation is 10 per cent of its former value, 90 per cent has been removed, and we may therefore state that the efficiency of the diaphragm is 0.90. In roentgenographing through six inches of water the efficiency is given by the equation,

$$E = \frac{4.9 - D/F}{4.9}$$

Figure 6 shows the efficiency plotted against ratio of slit width to slit depth.

In Table III are tabulated the values of D/T, D/F, exposure factor, and efficiency for several selected values of Ws/Ds; these values are taken from the curves of Figures 3 to 6. These values illustrate the high effi-

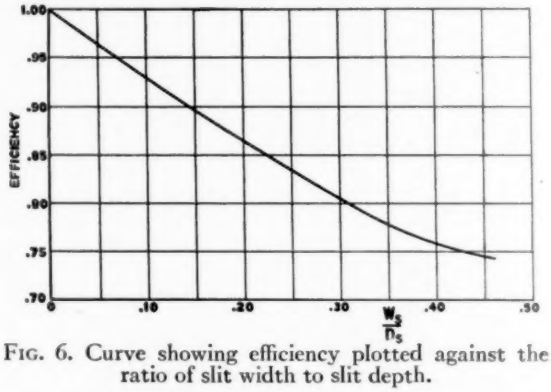


FIG. 6. Curve showing efficiency plotted against the ratio of slit width to slit depth.

ciency of the Bucky diaphragm; for instance a diaphragm for which Ws/Ds equals 0.30 removes 80 per cent of the diffuse radiation when Ws/Ds is 0.20, the efficiency is 86 per cent. Such ratios of slit width to slit depth are practicable, and they approximate the values used in the present commercial models of the Potter-Bucky diaphragm. Although such slit ratios allow considerable room for improvement, it is probably not advisable to use ratios much smaller than these in practice.

In a complete Bucky grid, the exposure factors given above must be increased to allow for the absorption of the filling material between the lead strips and for the area taken up by the thickness of the strips; the effect of these will depend upon the design of the grid and may increase the exposure as much as 20 or 30 per cent.

It is of interest to compare the effectiveness of the Bucky diaphragm principle with the method of reducing scattered radiation by circular diaphragms placed between the tube and the scattering material. This is done in the last column of Table III, which gives for each value of Ws/Ds the image size produced by a cir-

cular diaphragm having the same efficiency as the Bucky diaphragm principle; these image size values were taken from the curves obtained in a former investigation.[1] The table shows, for example, that a circular diaphragm allowing an image diameter of only 1.5 inches has the same efficiency in removing scattered radiation as a Bucky diaphragm with a slit ratio of 0.2.

TABLE III

| *Ratio Width to Depth of Slit Ws/Ds* | *Ratio Diffuse to Total Radiation D/T* | *Ratio Diffuse to Focal Radiation D/F* | *Exposure Factor* | *Efficiency* | *Image Diameter for Equal Efficiency by Circular Diaphragm (inches)* |
|---|---|---|---|---|---|
| 0.10 | 0.25 | 0.34 | 4.4 | 0.93 | 0.8 |
| 0.15 | 0.33 | 0.50 | 3.9 | 0.90 | 1.1 |
| 0.167 | 0.35 | 0.55 | 3.8 | 0.89 | 1.3 |
| 0.20 | 0.39 | 0.65 | 3.5 | 0.86 | 1.5 |
| 0.25 | 0.44 | 0.80 | 3.2 | 0.83 | 1.8 |
| 0.30 | 0.48 | 0.94 | 3.0 | 0.80 | 2.2 |
| 0.33 | 0.51 | 1.02 | 2.9 | 0.79 | 2.3 |
| 0.40 | 0.54 | 1.16 | 2.7 | 0.76 | 2.6 |

In making a complete Bucky grid, it has been found convenient to hold the lead strips in place by strips of wood; the question arises as to the effect of the wood filler upon the efficiency of the diaphragm and whether it is worth while to try to avoid the use of such a filler. The effect of the wood strips was measured for three sizes of the slit. The strips were made of beech wood; each one lacked $\frac{1}{16}$ inch of being as deep as the slit in which its effect was measured; this difference in depth was necessary to allow for the thickness of the cardboard cover of the film holder. The results of these experiments are recorded in Table IV; the fourth column of this table gives the value of D/T observed with the wood strip filling the slit; the fifth column gives the value of D/T for the empty slit as read from the curve of Figure 3. The wood strips are seen to have only a small effect upon the proportion of diffuse radiation affecting the film; the largest effect observed is scarcely greater than the possible experimental error of its determination.

TABLE IV

EFFECT OF WOOD FILLER IN BUCKY GRID

| *Slit Width Ws* | *Slit Depth Ds* | *Ws/Ds* | *D/T with Wood Filler* | *D/T for Empty Slit* |
|---|---|---|---|---|
| 0.083 | 0.37 | 0.22 | 0.43 | 0.42 |
| 0.13 | 0.65 | 0.20 | 0.42 | 0.39 |
| 0.20 | 0.65 | 0.31 | 0.52 | 0.49 |

## EXPERIMENTS ON DEFINITION

The effect of the Bucky diaphragm principle upon roentgenographic definition was studied with the aid of a set of copper wire gauzes, varying from 110 to 280 meshes per inch. They had been gold-plated to increase their absorption of *x*-rays. These meshes were mounted together between cardboard in a single row so that the whole set could be roentgenographed through the slit at one time. For each set of conditions, this definition test object was roentgenographed in two positions, one directly in contact with the slit, and the other immersed in the water at a distance of $1\frac{1}{8}$ inches above the slit. The exposures were adjusted to produce approximately the same density on the film in all the tests. The resulting roentgenographs were examined with a pocket magnifier giving a ten times magnification. The definition in any case was indicated by the finest mesh which could be resolved and was expressed in terms of meshes per inch. This definition test object gives a purely arbitrary scale of definition values, but it is very useful and convenient for comparing the definition obtainable under various conditions. The observations on the definition obtained with various dimensions of the slit are recorded in Table V. In column 4 is given the distance between the scattering material and the film; this is obtained by adding to the slit depth 0.06 inch, the distance of the tank above the slit. Where

TABLE V

EFFECT OF DIMENSIONS OF SLIT UPON DEFINITION

| *Slit Width in Inches Ws* | *Slit Depth in Inches Ds* | *Ws/Ds* | *Distance between Film and Scattering Material* | *Definition Test Object on Slit* | *Definition Test Object 1⅛ Inches Above Slits* |
|---|---|---|---|---|---|
| | 0.20 | 0.22 | 0.26 | >280 | 140 |
| 0.044 | 0.37 | 0.12 | 0.43 | >280 | 135 |
| | 0.65 | 0.068 | 0.71 | 245 | 120 |
| | 1.00 | 0.044 | 1.06 | 195 | 110 |
| | 0.20 | 0.42 | 0.26 | >280 | 135 |
| 0.085 | 0.37 | 0.23 | 0.43 | >280 | 130 |
| | 0.65 | 0.13 | 0.71 | 240 | 115 |
| | 1.00 | 0.085 | 1.06 | 185 | <110 |
| | 0.20 | 0.65 | 0.26 | 280 | 130 |
| 0.130 | 0.37 | 0.35 | 0.43 | >280 | 125 |
| | 0.65 | 0.20 | 0.71 | 235 | 115 |
| | 1.00 | 0.13 | 1.06 | 180 | <110 |
| | 0.37 | 0.465 | 0.43 | 280 | 125 |
| 0.172 | 0.65 | 0.265 | 0.71 | 230 | 115 |
| | 0.65 | 0.328 | 0.71 | 225 | 110 |
| 0.213 | 1.00 | 0.213 | 1.06 | 195 | ... |
| | 0.65 | 0.458 | 0.71 | 215 | 110 |
| 0.298 | 1.00 | 0.298 | 1.06 | 170 | ... |
| 0.432 | 1.00 | 0.432 | 1.06 | 165 | ... |

the definition comes outside the limits of the test object, it is designated as >280 (greater than 280) or <110 (less than 110). The conditions are the same as before; the tube was operated at 60 kv., roentgenographing through a 6 inch depth of water with a target slit distance of 25 inches. The films were given a standard development of five minutes in a tank Elon-hydroquinone developer at 65 degrees F.

The remarkable fact shown by these data is the loss in definition as the slit is deepened without changing its width. Increasing the depth of the slit diminishes the intensity of diffuse radiation in nearly the same proportion, thereby improving the roentgenographic contrast, but the definition is poorer than before. The definition diminishes gradually with an increase in the width of the slit. As regards definition, therefore, the controlling factor is the distance of the film from the object roentgenographed; to get the best definition the slit should be as shallow as possible while at the same time a fairly efficient ratio of slit width to slit depth is maintained.

In a practical Bucky grid the lead strips should not be brought too close together, or the thickness of the strips will form too large a proportion of the total area of the grid and absorb a large part of the focal rays. If now the grid is made shallow in order to obtain the best possible definition, the ratio of slit width to slit depth will be somewhat larger than that consistent with the highest efficiency in removing scattered radiation; thus some gain in contrast must be sacrificed in order to improve the definition. It is believed this is the better procedure, however, to make definition the first consideration. Any slit ratio within the range investigated will remove most of the scattered radiation and considerably enhance the contrast, and this combined with the best attainable definition should give the maximum efficiency in the depiction of fine detail.

The factors in grid design which govern definition are the ratio of slit width to slit depth and the distance between the subject roentgenographed and the film, the latter factor being of the greater importance. In using Table V to estimate the definition given by any Potter-Bucky diaphragm, only these two factors (given in columns 3 and 4) should be employed as specifying the essential characteristics of the grid.

It is evident that in a complete working Bucky diaphragm there should be no waste space between the top cover and the grid or between the grid and the film. In order to obtain the same fine definition over the whole area of the roentgenograph the cassette should conform to the curvature of the grid, thus bringing all parts of the film as close as possible to the subject. The curved cassette has been recommended by Dr. Van Allen[5] who finds that it reduces both the distortion and the fuzzy appearance (poor definition) which are characteristic of objects distant from the film.

Some tests were also made of the definition attainable by the ordinary technique with no reduction of the scattered radiation; and a few experiments were carried out to determine the definition obtained with a circular diaphragm placed above the scattering material as compared with the definition given by the Bucky diaphragm; in these tests the film was placed directly beneath the tank; otherwise the conditions were the same as those employed in the tests of the Bucky diaphragm principle. The results of these tests are given in Table VI.

TABLE VI

EFFECT OF CIRCULAR DIAPHRAGM ABOVE SCATTERING MATERIAL IN IMPROVING DEFINITION

| *Image Diameter in Inches* | *Definition* | |
|---|---|---|
| | *Test Object on Film Holder* | *Test Object 1⅛ Inches Above Film* |
| 25 | 225 | 120 |
| 4.5 | 280 | 140 |
| 3.0 | >280 | 145 |

Upon comparing the data of Table V with those of Table VI it will be noted that in every case where the film is 1.06 inches below the scattering material, the definition is poorer than that obtained by the ordinary technique with no precautions against scattered radiation. Such a diaphragm is of no benefit in roentgenographing through a layer six inches in depth; the thickness would have to be somewhat greater than six inches to make the use of the diaphragm advantageous. With the

film 0.71 inch below the scattering material, a slit ratio (Ws/Ds) of 0.26 gave a definition nearly equivalent to that of the ordinary technique. Such a diaphragm would be advantageous in roentgenographing through a thickness of six inches on account of the improvement in contrast, even though it gave no improvement in definition. Smaller slit ratios at the 0.71 inch distance (between scattering material and film) gave somewhat better definition than the ordinary technique. In every case where the film was less than 0.43 inch below the scattering material, better definition was obtained than by the ordinary technique, considerable improvement being produced by the smallest slits.

It will also be noted that a circular diaphragm limiting the image diameter to 3 inches gives slightly better definition than was obtained with the smallest slit used. It is evident that on account of the distance between the subject roentgenographed and the film, the Bucky-diaphragm principle is not as effective in improving definition as in improving contrast; but by reducing the thickness of the grid so that the distance between subject and film can be made as small as possible, the Bucky diaphragm can be made to produce a considerable improvement in definition as well as a marked increase in contrast.

A few simple tests were made to determine whether a crossed grid of the original Bucky type would give any radical improvement over the slit type devised by Potter. A single element of such a grid was duplicated by blocking up most of the slit with strips of lead, leaving only a small square hole for the passage of *x*-rays. The definitions obtained in these experiments are recorded in Table VII.

TABLE VII

| *Dimensions of Grid Unit* | *Definition* *Test Object on Slit* | *Test Object 1⅛ Inches Above Slit* |
|---|---|---|
| 0.05 inch square by 0.20 inch deep | >280 | 145 |
| 0.08 inch square by 0.37 inch deep | >280 | 140 |

The definition obtained in these tests is only slightly better than that obtained with a long slit of equal depth and approximately equal width. In view of the mechanical difficulties of making a crossed grid of the original Bucky type (resembling a honeycomb) so designed and moved that it would not show shadows of the grid, it seems that the slight advantage to be gained is scarcely worth the cost. The most promising and practical procedure would be to push the Potter type of grid to the limit of its effectiveness.

A few experiments in definition were made with a 4 inch thickness of water as the scattering material. With the film 0.43 inch below the tank of water, a slit ratio of 0.24 gave practically the same definition as the ordinary technique. Keeping the slit width the same (0.088 inch) the distance between scattering material and film was reduced to 0.26 inch; this produced an appreciable improvement in the definition; the slit ratio in this case was 0.44. A smaller slit ratio than this would doubtless be feasible in a thin Bucky grid, and it would improve both the definition and contrast in roentgenographs of thicknesses as small as 4 inches.

In studying the effect of the wood filler upon definition, the data shown in Table VIII were obtained. The wood was found to have only a slight effect; in the small slits which were found to give the best definition, the effect of the wood filler is practically negligible.

TABLE VIII

EFFECT OF WOOD FILLER UPON DEFINITION

| *Slit Width Ws* | *Slit Depth Ds* | *Ws/Ds* | *Definition with Wood Filler* *Test Object On Slit* | *Test Object 1⅛ in. Above Slit* | *Definition without Filler* *Test Object On Slit* | *Test Object 1⅛ in. Above Slit* |
|---|---|---|---|---|---|---|
| 0.083 | 0.37 | 0.22 | 280 | 135 | >280 | 135 |
| 0.15 | | 0.41 | 280 | 125 | >280 | 125 |
| 0.079 | | 0.12 | 240 | 120 | 245 | 120 |
| 0.13 | 0.65 | 0.20 | 230 | 115 | 235 | 115 |
| 0.20 | | 0.31 | 215 | 110 | 225 | 110 |
| 0.27 | | 0.42 | 205 | 110 | 215 | 110 |

The thickness of the lead strips should be such as to absorb nearly all of the scattered rays incident upon them; the minimum thickness of lead required to do this has not been determined, but it is hoped that experiments to be carried out later will give some information on this point. The data of Richtmyer on

absorption should be of considerable assistance in estimating the proper thickness of the lead strips.[6]

The increased exposure required by the Bucky diaphragm makes the use of intensifying screens necessary in most cases. In order to secure the fullest advantage of the improvement afforded by the diaphragm, the screens used with it should have the best possible definition, and the requisite precautions should be taken to insure good contact between the screens and the films.

In this study of the Bucky diaphragm principle, no attempt has been made to deal with the mechanical features of the Bucky diaphragm. A well designed mechanism for operating the diaphragm is as essential as an efficient grid for the production of satisfactory roentgenographs. There is opportunity for much ingenuity in devising a mechanism which gives a smooth uniform motion to the grid and which can be operated with a minimum of attention on the part of the roentgenologist or technician.

## SUMMARY

Using a 6 inch depth of water as the scattering material, the efficiency of the Bucky diaphragm in removing scattered radiation has been measured for a variety of widths and depths of slit. The intensity of diffuse radiation was found to be a function of the ratio of slit width to slit depth, not depending upon the actual size of the slit. The Bucky diaphragm was found to be highly efficient, it being easily possible to remove more than 80 per cent of the scattered radiation. The wood filler used to support the lead strips has only a slight effect upon the efficiency of the diaphragm; for small sizes of slit its influence is practically negligible.

The definition obtainable with the Bucky diaphragm depends chiefly on the distance between the subject roentgenographed and the film; by making this distance sufficiently small the Bucky diaphragm can be made to give a considerable improvement in definition over the ordinary technique, and can be used with advantage in roentgenographing thicknesses as small as 4 inches.

The crossed grid of the original Bucky type (resembling a honey-comb) gives very little advantage over the Potter type of grid with the same depth of slit; it is concluded that the best practical improvement of the Bucky diaphragm lies in pushing the Potter type of grid to the limit of its effectiveness.

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## DISCUSSION

Dr. A. H. Pirie. Mr. Wilsey mentioned that if you cut down the diaphragm and make a picture 3 inches in diameter you get as good results. Acting on that principle I used to take spines this way. I had a sliding diaphragm between the tube and the patient. It consisted of a sheet of lead with a transverse slit through which the rays passed. For taking spines I found it increased the detail very much. However, it increased the length of exposure so much that I gave it up. It improved the spine pictures very much ten years ago.

Mr. Wilsey. The chief value of the data I have shown lies in its quantitative character, which enables us to estimate more precisely how far in any one direction it is worth while to go in trying to improve the Bucky grid.

Regarding gallstone technique, I would hesitate to make any suggestions; not being a roentgenologist, I can investigate and report only upon the physical factors involved. When it comes to the practical application of this information, you have in your work motion of the patient and other factors which must be taken into account. The roentgenologist must take this information and apply it with his own special knowledge to determine what technique is likely to give the best results in any given case. I feel sure that if the diaphragm is altered in the way suggested by making the slit more shallow, the definition will be much improved.

Dr. Cole has done a great deal of work with the double slot method and undoubtedly it would have many advantages. By having a slot both above and below the patient, scattered radiation can fall only on that part of the film that is being exposed to the focal rays. This method would permit a very short distance between patient and film. Whether or not the double slot method is superior to the Bucky diaphragm, I have no measurements to determine. As Dr. Cole well knows, the chief difficulty with the method at the present time is the heavy continuous tube current required to make a full size roentgenograph.

I doubt if there is any appreciable advantage in using the combination of a cone above the patient with the Bucky diaphragm beneath. The advantage in using the cone by itself without the Bucky diaphragm lies in the short distance between the film and the patient.

# SIGNAL LIGHT FOR BUCKY-POTTER DIAPHRAGM

BY JOHN H. LINDSEY, M.D.

FALL RIVER, MASSACHUSETTS

THE noise of an *x*-ray machine may obtund the sound of the signal bell of a Bucky-Potter diaphragm.

The suggestion having been made that a signal light was a practical attachment, the bell was disconnected and an electric lamp was placed on the wall of the *x*-ray room. This lamp was connected with a wall-socket and with the Bucky-Potter diaphragm in such a manner that the light would appear when the sliding grid made the contact. As a signal this arrangement was satisfactory, but difficulty was experienced in insulating the Bucky-Potter diaphragm. Moreover, the wall attachment is not readily portable.

Another device consisted in the attachment of a small electric lamp to the side of the Bucky-Potter diaphragm. Power for this lamp was furnished by two batteries which could be placed under the table or by the side of the table upon a convenient support. As a signal this arrangement also was satisfactory, but the batteries and wires proved clumsy and entangling.

As a third development a small tubular pocket flash-light was attached to the side of the Bucky-Potter diaphragm as shown in the illustration. This arrangement permits of better mechanical adjustment, but the device is very satisfactory as it is, and can be recommended as an efficient substitute for the bell.

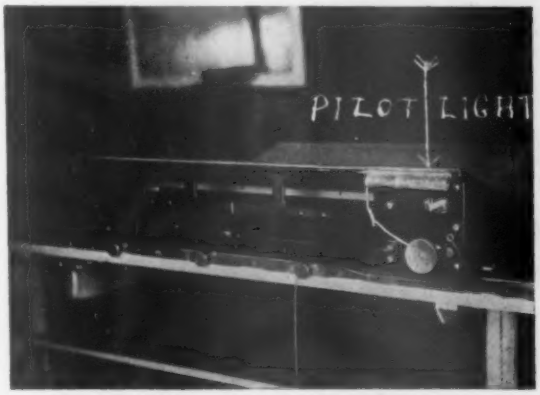


FIG. 1. Tubular pocket flash-light attached to Bucky-Potter Diaphragm.

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*Editors*: H. M. IMBODEN, M.D. - - JAMES T. CASE, M.D.
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*Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.*

## CENTRAL SECTION

### THIRD ANNUAL MEETING

The Third Annual Meeting of the Central Section of The American Roentgen Ray Society will be held at the Congress Hotel, Chicago, on February 22, 1922.

An interesting program of about twelve or fourteen papers will be offered. In the evening, a banquet will be held at the hotel, followed by a lantern slide exhibit.

Communications regarding the meeting may be addressed to the President, Dr. William M. Doughty, 628 Elm Street, Cincinnati, Ohio.

## AMERICAN RADIUM SOCIETY

### NOTICE OF ANNUAL MEETING

The Seventh Annual Meeting of the American Radium Society will be held at St. Louis, Missouri, on Monday and Tuesday, May 22nd and 23rd, 1922, immediately preceding the meeting of the American Medical Association. Those having new ideas or desiring to make presentations or to read a paper will please communicate at once with Dr. Henry K. Pancoast, Chairman of the Program Committee, Thirty-fourth and Spruce Streets, Philadelphia. A partial program has already been prepared, which promises much. Headquarters will be at the Planters Hotel where the meetings will also be held. Inasmuch as this hotel accommodates only 450 guests it would be wise to make reservations at once.

## PACIFIC COAST MEETING

The Pacific Coast Roentgen Ray Society held its fifteenth semi-annual meeting in Phoenix, Arizona, on December 1st, 2nd and 3rd. The Society attempted an innovation at this meeting which proved to be successful to the highest degree. Arrangements were made to amalgamate their meeting with that of The Medical and Surgical Association of the Southwest, presenting a conjoined program. The Chairman of the Program Committee was Dr. W. Warner Watkins, of Phoenix, who is the President of the Pacific Coast Roentgen Ray Society. A creditable display of *x*-ray films in original form, in reduced form and in lantern slides, were placed on exhibition throughout the meeting and attracted wide attention, the exhibit being thrown open to the public during one evening.

Both organizations expressed themselves as highly pleased with the arrangement. The papers presented by the roentgenologists were all designed to appeal to clinicians, technical features being avoided and clinical points being emphasized. The papers read by members of the Roentgen Ray Society to the general meeting were as follows:

*Fractured Vertebrae.* Dr. W. B. Bowman, Los Angeles, read in the Symposium on Bone Lesions.

*Roentgenology in Heart Diseases.* Dr. Rolla Karshner, Los Angeles.

*Aortic Lesions and Life Expectancy.* Dr. Roy Payne, Portland. Symposium on Chest and Heart.

*Non-Calculous Cholecystitis—a Plea for its Recognition and Surgical Treatment.* Dr. W. P. Burnham, San Francisco.

*Gastric Polyposis.* Dr. Lloyd Bryan, San Francisco. Symposium on Abdominal Lesions.

*Action of Radiation on Tonsillar and Hypertrophied Lymphoid Tissue.* Dr. Albert Soiland, Los Angeles.

*Non-malignant Conditions of the Uterus and Radiotherapy*. Dr. John W. Cathcart, El Paso, Texas.

On Thursday night, the lantern slide show of the Society was given, introduced by a paper by Dr. Raymond Taylor of Los Angeles, on "Causes of Abdominal Pain, as found by Roentgen-Ray Examination."

Films or slides for exhibition were sent in by Dr. Willis H. Watson, of Portland, Ore., Dr. A. C. Siefert of Oakland, Calif., Dr. C. J. Johannesson, of Walla Walla, Wash., Dr. H. H. Heylmun, of Long Beach, Calif., Dr. Wm. H. Sargent, of Oakland, Calif. W. W. W.

## CORRESPONDENCE

*To the Editor*:

In reading Dr. Pirie's article on the supernumerary bones, in the October issue, I was impressed with what he said in reference to the ossicle appearing in connection with the pedal scaphoid. My attention was first called to this supernumerary bone by Dr. A. J. Pacini, who had a print very closely resembling Dr. Pirie's Figure 12.

Some time later I came across a case showing this bone bilaterally. Having had access to the Surgeon General's library, I spent many hours searching the literature in the hope of finding a description of this rare bone. In this I believe I was partially rewarded. I found that Hyrtl[1] described a "trochlear process" on the posterior edge of the dorsal surface of the scaphoid at a point at which a line drawn bisecting the dorsal surface of the second metacarpal crosses the posterior edge of the scaphoid.

This, undoubtedly, is not the bone to which Dr. Pirie refers.

[1] HYRTL. Über die trochlearforsätze der menchlichen Knochen. *Denkschr. d. k. Akad. d. Wissensch. Math.-naturw. Klasse, Wien*, 1860, xviii, 141.

Pfitzner[2] describes an ossicle as a "supranaviculare (spurium?)" and says that it is situated on the posterior edge of the dorsal surface of the naviculare and articulates with the caput tali. In none of his writings does he illustrate this ossicle, but he does say that he considers it to be equivalent to Hyrtl's case. Pfitzner's description of his observation does not agree with the figure of Hyrtl's case. It may be that Pfitzner's case was also a "trochlear process," but he gives the impression that he really suspected the presence of a supernumerary ossicle which he called the "supranaviculare (spurium?)," probably adding "(spurium?)" to show his doubt.

Personally I believe that "supranaviculare" is a good descriptive name for this rare ossicle.

Respectfully,

MORRIS I. BIERMAN
Assistant Surgeon (Roentgenologist)
United States Public Health Service
Minneapolis, Minn.

## OBITUARY NOTICE

We announce with deep regret the death on January 5th of Dr. James Gerritt Van Zwaluwenburg, Professor of Roentgenology at the University of Michigan, for many years a member of The American Roentgen Ray Society, and past President of the Central Section. An obituary will appear in a forthcoming issue of the JOURNAL.

## A CORRECTION

In the article by Dr. Samuel Stern in the December issue of the JOURNAL, entitled "Intensive *X*-Ray Therapy as Seen Practiced in the Clinics in Europe," on page 741, first column, the heading "Frankfort Frauen Clinic" should read "Freiburg Frauen Clinic."

[2] PFITZNER. Die Variationen im Aufbau des Fuss-skeletts. *Morphol. Arb.*, 1896, vi, 245.

*Subscribers to* THE AMERICAN JOURNAL OF ROENTGENOLOGY *visiting New York City, are invited to make the office of* THE JOURNAL (*69 East 59th Street, New York*) *their headquarters. Mail, packages or baggage may be addressed in our care. Hotel reservations will gladly be made for those advising us in advance; in this case, kindly notify us in detail as to requirements and prices. List of operations in New York hospitals on file in our office daily.*

# BOOK REVIEWS

X-RAYS AND RADIUM IN THE TREATMENT OF DISEASES OF THE SKIN. By George Miller MacKee, M D., Assistant Professor of Dermatology and Syphilology, College of Physicians and Surgeons, Columbia University; Consulting Dermatologist and Syphilologist, St. Vincent's Hospital, New York. Contains 602 pages with 250 engravings and 22 charts. Price $9. Lea & Febiger, Philadelphia, 1921.

A modern book dealing with *x*-ray and radium therapy of diseases of the skin has been sorely needed for years. MacKee is the logical man to write one for he has had more experience with measured roentgen rays than any other man in America

The plan of the book has been carefully thought out. The first three hundred pages deal with history, physics, *x*-ray apparatus, dosage, filtered and unfiltered technique, the chemical, biochemical and biological effects of *x*-ray and radium, radiodermatitis, with idiosyncrasy and general therapeutics considered, while the last two hundred and fifty pages take up the various diseases in detail. In addition there is a chapter devoted to the medico-legal relations of radiation.

MacKee wisely believes that no one should employ either *x*-ray or radium without a thorough knowledge of the physics of this agent, and both a theoretical and practical knowledge of just what their action is.

The chapter upon general physics is excellent. Much space is devoted to all types of *x*-ray and radium apparatus. All methods of estimating dosage are dealt with in detail. The statement as to the value of various instruments and methods is cleancut and decisive.

The chapters dealing with the various diseases are, to the mind of the reviewer, very justly handled. MacKee does not recommend radiation where other methods give better results, and a wide dermatological training enables him to speak authoritatively upon this subject. For instance, he does not recommend radiation for squamous-celled cancer of the lips.

The illustrations are profuse, well chosen, and excellent. There is an admirable bibliography. Very few typographical errors have been noted.

It is possible that the men who are devoted to radium will feel that the *x*-ray is over-emphasized and radium slighted. But as a matter of fact no one should employ radium who is not thoroughly acquainted with the general subject of both roentgen rays and radium. In addition, the roentgen ray is so much more valuable to the dermatologist that it is justly entitled to more space.

One or two minor criticisms can be made. For instance, more advice might well be given in regard to the selection of equipment. In regard to *x*-ray equipment attention should be called to the fact that it is always wise to buy from a house which is prepared to render adequate service in the particular locality where the purchaser resides. It is a little difficult to see why "callositas" is used as a synonym for "verruca plantaris." In discussing leukoplakia mention is not made of the necessity of removing any irritating teeth.

In general it may be said that the book is safe, sane, conservative and complete. It is absolutely indispensable to every radiologist and dermatologist and should be in the hands of all men who see many skin affections. Let us hope that ere long we shall have an equally good work upon deep *x*-ray and radium therapy.

H. H. HAZEN.

# TRANSLATIONS & ABSTRACTS

MOPPERT, G. G., (Geneva). Radioscopic Measurements Showing the Great Frequency of Spontaneous Biliary Reflex into the Stomach. (*Presse méd.*, May 25, 1921, xxix, 42.)

The author refers to the Einhorn thread test in gastric and duodenal ulcer. The measurements used by Einhorn were as follows: distance of cardia from dental arch, 40 cm.; lesser curvature 44 to 54 cm.; pylorus 56 to 58 cm., and duodenum 59 cm. The author in an article published last March showed that these reference figures are inaccurate. The thread is often stained by patients free from ulceration, while the pyloric distance shows considerable variation. The author has sought by means of the screen to show the actual distance of the pylorus from the dental arch. He uses Einhorn's thread and technique. When the capsule is withdrawn resistance is felt at the pylorus and at this juncture a mark is made on the thread at the level of the dental arch. The thread is then withdrawn entirely, and the distance read off and compared with that of the beginning of the bile stain. Of 128 threads examined 46 had never left the stomach, while 82 had entered the pylorus. The location of the latter was shown on the string in 32 cases. In these the figures varied extremely, from 47 to 77 cm. The measurements of Einhorn held good in about 35 per cent. If we compare the thread findings with the roentgenograms of the same subjects we shall find that this difference in measurements is in part due to factors readily intelligible. Thus in the short distances the stomach is presumably hypertonic and in the extra long distances hypo- or atonic. Distances midway between the two mean an orthotonic or normal stomach, which suggests that the measurements of Einhorn were made on normal subjects or rather on subjects with some hypotonia, for the orthotonic should show a length slightly under 56 to 58 cm. Hence the thread has a diagnostic value possibly greater than Einhorn had in mind in introducing it; since by it alone it should be possible to diagnosticate atony or hyperatony. The position of the bile stain coincides fairly well with that of the pylorus although in but 3 of 30 cases was the coincidence exact. The stain often began considerably above the pylorus, which illustrates the frequency of reflux through the pylorus, and in only one did it begin beneath the pylorus.

Concerning the numerous cases in which the string never traversed the pylorus, this was clearly due in a large proportion—(the author believes two-thirds)—to pylorospasm or organic stricture, which fact gives further diagnostic possibilities to the string test. But the string is not always held back by pyloric stenosis, for it was retained to some extent in a third of the cases in which the pylorus was patent as demonstrated on the screen. Tests by the author show that the site of the bile stain is not prejudiced by the possibility of capillary attraction exerted along the course of the thread. The weight of the evidence is that reflux of bile from the duodenum into the stomach is a common and spontaneous phenomenon.

VAN ZWALUWENBURG, J. G. and GRAHFIELD, G. B. The Tonsillar Route of Infection in Pulmonary Tuberculosis. (*Am. Rev. Tuberc.*, March, 1921.)

The writers describe a shadow which they believe represents a thickening of the pleura over the apex of the lung, and studied its relationship to tonsillar and cervical gland tuberculosis. Ten per cent of all roentgen ray examinations of the chest coming to the University laboratory show such apical pleuritis. This shadow is seen in 93 per cent of the cases having tuberculous deposit in the faucial tonsils. This lesion probably occurs in a large number of cervical gland tuberculosis and is recognizable in 59 per cent, 71 per cent in this group showing either this lesion, or frank tuberculosis of the lung or both. Only 11 per cent of non-tubercular tonsil cases show an apical pleuritis. A common route of infection may be through the tonsil and the cervical lymphatics to the apical pleura and then to the lung.

ROY G. GILES.

COLE, H. N., LITTMAN, S., and SOLLMANN, T. Study of Mercuric Injections by Means of the Roentgen Ray. (*J. Am. M. Assn.*, December 4, 1920, lxxv, 23.)

The authors of this article in a most able manner show rather definitely that the injection of mercuric substances into the muscles should be done with caution; and they prove that not only may this procedure become dangerous to the patient but that as a therapeutic means it often fails. They show by rather extensive experiments that absorption of insoluble mercuric preparations from intramuscular injections can be followed very satisfactorily by the roentgen ray shadows. This method cannot be applied to the soluble

mercuric preparations. Study of clinical cases proves the following with regard to the time required for complete absorption.

Mercuric salicylate requires as a mean, 4 days, and as extremes from 4 to 10 days, for complete absorption by gluteal muscles. For complete absorption by lumbar muscles: mean, 8½ days; extremes from 2 to beyond 24 days.

Injections of calomel require for absorption as a mean, 15 days; extremes from 4 to 39 days. They state that gray oil was unabsorbed during their entire period of observation. It gave approximately a mean of 43 days; extremes from 16 to 125 days, which would indicate that gray oil injections are inefficient and dangerous and their use should be abandoned. They also state that calomel injections are dangerous.

Their conclusions in regard to mercuric salicylate injections are that when given especially into the gluteal muscles they show satisfactory absorption and present relatively little danger. They recently have seen a case of poisoning from gray oil injections four months after receiving the drug. This was proven by the *x*-ray examination which revealed a large mass of metallic mercuric globules.

W. W. Belden.

Clark, J. G., and Keene, F. E. Irradiation in Cancer of the Female Genito-Urinary Organs: Results in Three Hundred and Thirteen Cases. (*J. Am. M. Assn.*, August 20, 1921, lxxvii, 613.)

The writers report 313 cases treated prior to August, 1920, of whom 112 are living and 201 are dead. Of the living cases, 13 have had fistulas; 21 fistulas occurred among the 201 dead. Of the 201 dead, 60 remained free from local recurrence, death being caused by metastasis. Doubtless a larger number would have developed fistulas as a natural incident of bladder or rectal invasion, had they not been treated by radiation. The plan followed in general with at least 150 cases was the application of 100 mg. of radium screened with platinum and rubber for twenty-four hours, the healthy tissues being protected by lead. Most of the fistulas occurred in this group. The present technique does not include lead protection, protection being afforded to the neighboring tissues by means of gauze packing. Routine repetition of treatments is injudicious. The writers are inclined to limit radiation to those cases in which there is a visible or palpable localization of the gross changes. Advanced cases may be rendered worse by radium therapy, because the cells at the periphery of a widespread growth may be stimulated to activity. In cases in which a progressive favorable action is noted after six weeks, the patient is advised to return again in six weeks more. If a white hyaline cicatrix is seen covering the site of the ulcer, further action is delayed. In those cases in which no progress is noted one more application is made. If no progress be noted, further irradiation is abandoned.

The patient is given gas; if there is a cauliflower growth it is removed with the cautery. Fifty mg. of radium are introduced into the cervical canal, and a similar tube is held within the crater or against the vaginal portion of the cervix with fine catgut sutures. Needles may be inserted into the appropriate areas. The vagina is thoroughly packed with gauze.

In cancer of the fundus, operation is advised. "In cancer of the cervix, when in doubt always irradiate; in cancer of the fundus, when in doubt operate."

Ante-operative irradiation and post-radiation surgery are equally ill-advised. Irradiation soon after operation, or in fresh operative fields is dangerous.

Several statistical tables are set forth covering 313 cases. There were 214 cases of cervical carcinoma, of whom 56 are alive from one to seven years after treatment, 9 were untraced. 140 are dead (23 lived more than two years), and 8 are untraced. There were 23 cases of inoperable carcinoma of the fundus, of whom 12 are living one to six years after treatment, and 11 are dead. There were 2 cases of chorio-epithelioma, both alive six and seven years after treatment. Four cases of carcinoma of the cervical stump are alive, one and one-half to four years after treatment. Of 21 cases of recurrent carcinoma of the vagina after hysterectomy, 7 are living at periods of from one to five years after treatment, and 14 are dead.

L. S. Goin.

Schmitz, H. The Treatment of Cancer of the Uterus. (*J. Am. M. Assn.*, August 20, 1921, lxxvii, 608.)

The objects of this study are to discuss the prophylaxis of uterine cancer, to review briefly the diagnosis of carcinoma of the uterus, to group correctly the various stages of the disease, and to base the indications for a correct treatment on such a grouping.

Cases which are clearly localized after a physical examination are operable cases and are treated by abdominal pan-hysterectomy. Cases which appear to be doubtfully localized after a physical examination—borderline

cases—and operable cases which are poor surgical risks owing to complicating constitutional disease, form the ideal group for radiation therapy. Cases in which a demonstrable invasion of the contiguous tissues and organs and regional lymph-nodes is found on physical examination are clearly inoperable and are subjected to intensive radiation. Hopeless and terminal cases are treated symptomatically.

The duration of an application of radium within the cervical canal depends upon the intensity of the radiation striking the rectal mucosa. This limits the extent of the action of radium in the pelvic cavity; the parts lying near the bony periphery do not receive an adequate dosage. This may be remedied by supplementing radium therapy by intense doses of *x*-ray. Surgery in connection with such treatment is not advisable, as these patients undergo a profound radiation toxemia, and succumb easily to sepsis and shock. The technique for combining *x*-rays and radium is outlined.

In the treatment of recurrences, the radiation must be as intense as though the uterus had not been removed, regardless of the consequences. The disease and not the patient must be treated. Pre-radiation curettage and cauterization or post-radiation panhysterectomy in the clearly inoperable cases render the patient's chances for even temporary improvement decidedly worse. An active immunization is produced by the action of radium on malignant cells, the cancer cells being stimulated to produce a specific antibody for other similar cells in the tissues of the patient being treated. Hence it is inadvisable to remove cells, the presence of which are necessary for the production of an antibody.

From April, 1914, to December 31, 1919, 168 cases of uterine cancer were treated with radiation. In some cases treatment was preceded by surgical procedures; as hysterectomy or cauterization, and in others radiation was followed by hysterectomy. Since 1918 radiation was used exclusively. The results show as apparent cure: 71.4 per cent operable cases; 54.5 per cent borderline cases; 27.9 per cent inoperable cases; 2.5 per cent terminal cases, and 2.2 per cent of recurrences.

L. S. G.

Duncan, R. D. Uterine Cancer: With Observations and Results of Treatment with Radium in More Than 300 Cases. (*J. Am. M. Assn.*, August 20, 1921, lxxvii, 604.)

The writer shows by a series of tables that the operative treatment of cancer of the uterus, even by the most skilled surgeon, is not satisfactory. Similar tables show encouraging results from radium therapy. The cases reported are not so numerous however, and the periods elapsing between treatment and report are variable.

The technique employed is the introduction of screened emanation tubes into the uterine cavity, supplemented, when necessary, by vaginal applicators, and in certain cases by burying needles or tubes in the tumor. The total dosage employed is from 4,000 to 6,000 millicuries hours, depending on the size and character of the uterus.

No toxemias have been noted. There has been little annoyance from bladder irritation, but in cases with involvement of the posterior vaginal wall a severe rectal tenesmus develops in ten days and continues for about two weeks.

The results consist in a gradual absorption of the cancer tissue, disappearance of the vaginal ulceration and new growth, and local healing of the cervix. The uterus reduces in size and becomes less fixed. Surgery following an apparent cure from radium is not only unnecessary but often disastrous.

The writer reports 236 cases treated with radium. An average of all cases shows 40.6 per cent clinically well. The results vary from 22 per cent clinically well after treatment for recurrent carcinoma to 86.6 per cent clinically well in the operable cases.

L. S. G.

Boggs, R. H. The Treatment of Tuberculous Adenitis by Roentgen Ray and Radium. (*Am. J. M. Sc.*, July, 1921, clxii, 90.)

Formerly roentgenotherapy was used in tuberculous adenitis to avoid deformity and scarring; now it is used on a definite therapeutic basis. Over 90 per cent of all tuberculous adenitis cases can be cured by roentgenotherapy. Tuberculous adenitis is no longer a surgical disease, it is merely a local manifestation of a general condition. Tonsils, if involved with tuberculosis, should not be removed until the cervical glands have been rayed to close off the lymph channels, especially in children under fifteen years of age.

The reasons given against surgical intervention are:

1. Children get well without it.
2. We have no certain method of diagnosis in early cases.
3. All affected glands cannot be removed.
4. Scars.
5. Recurrences.

Since the disease can be removed more successfully by roentgen ray or radium with no danger of spreading the disease, without scar-

ring and without sacrificing tissue, complete extirpation of the tuberculous glands should never be performed until the disease is well localized Immediate opening of a tuberculous abscess is even counseled against, as being liable to disseminate the infection; close off the lymph channels just with radiation. Ultimate healing will be hastened. The lymph glands are the lines of the first defense. Overcoming this barrier, the bones are next involved and finally the lungs are affected. Left untreated and unaided in the fight, tuberculous adenitis may progress to more serious involvement. In conclusion:

1. Radium and the *x*-ray will cure more cases of tuberculous adenitis than any other method. Roentgenotherapy alone will cure over 90 per cent of these cases.

2. Surgical treatment is always contraindicated in every case of tuberculous adenitis.

3. Those who still hold to radical operation will find the responsibility hard to shoulder with the ever increasing recognition of the fact that tuberculous adenitis can be cured without it.

4. Hard fibrous nodules following roentgenotherapy seldom contain any tuberculous foci, but it may be permissible to remove these nodules through a small incision the same as with a foreign body.

5. It is to be remembered that large cervical glands may be due to sarcoma, Hodgkin's disease, leukemia, etc., and that roentgenotherapy is still the best form of treatment for multiple glandular tumors, but the end results are not the same as when the enlargement is due to tuberculosis.

6. In the treatment of tuberculous adenitis in the future, when a more systematic raying is employed and when the cases are referred earlier, this method of treatment will be universally accepted.

L. R. Sante.

Sachs, E. The Diagnosis and Treatment of Brain Tumors. (*J. Missouri M. Assn.*, July, 1921, xvii, 217.)

Attention is called to the marked progress in the diagnosis and treatment of brain tumors in the past decade. The localizing symptoms of brain tumors in different localities is taken up. Concerning the *x*-ray in diagnosis of brain tumor the writer says:

"Another method that I feel should be made use of in every case is the *x*-ray. There are only a limited number of cases in which it is of real value, but one never can know beforehand when the diagnosis may be strikingly confirmed by the *x*-ray. I have stereoscopic plates taken in every case and study the plates myself with the roentgenologist. A special technique is necessary, for the position of the patient's head on the plate is of great importance. The plate may reveal the following points:

1. General signs of increased pressure. The appearance of a so-called pressure skull is characteristic. The areas of convolutional atrophy are due to thinned bone at the site of the convolutions.

2. The sutures may be separated in children or young adults.

3. The conformation of the dorsum sellae may be significant; when there is general increased pressure the dorsum sellae may be thinned and pressed forward, while in lesions originating in the sella turcica—pituitary tumors—the dorsum is pushed backward. In very advanced cases the dorsum may be completely destroyed. A large deformed sella is, of course, noted in cases of pituitary tumor, though this is not always the case, for the tumor may lie above the pituitary fossa.

4. In tumors in the cerebello-pontine region, particularly acoustic nerve tumors, comparative studies of stereo-plates of the right and left sides may reveal an enlarged internal auditory meatus. These plates are the most difficult of all to take and require a most painstaking technique.

5. In a few cases there may be a shadow due to calcified deposits in the tumor. When this is found it is of great value and importance.

Concerning the treatment of brain tumors, other than operative, roentgenotherapy is mentioned as holding forth considerable hope.

The writer feels that it is too early to express a final opinion on this subject, but it seems from the cases thus far reported that the application of radium or the *x*-ray, after a tumor removal through a decompression opening, helps to inhibit the growth and possibly to destroy the remaining vestiges of a tumor that has been removed.

L. R. S.

Gellhorn, G. Roentgenotherapy in Non-Malignant Diseases. (*J. Missouri M. Assn.*, July, 1921, xvii, 220.)

The question of the real therapeutic value of *x*-rays and radium in gynecologic diseases is no longer open for argument; it merely remains to enumerate the non-malignant conditions (to which this paper is limited) in which it is of distinct benefit.

Chronic metritis, especially prevalent in women near the menopause, causes severe protracted hemorrhages which often resist every other method of treatment. All observers agree

that these hemorrhages can be checked with absolute certainty. In 95 per cent the recovery was complete; of the remaining 5 per cent recurrences occurred in about 3 per cent, but with a repetition of radiotherapy only 2 per cent finally failed to respond. It should be borne in mind that hemorrhages at this age are very often due to carcinoma of the uterus and this condition should be definitely excluded in all cases before undertaking such palliative therapy. Operation alone is justifiable in carcinoma.

The second principal field for therapy is in the treatment of fibroid. Even in the hands of excellent surgeons there is still a mortality of 3 to 5 per cent. Roentgenotherapy has no mortality. The word "cure" means something different in the two methods; by operative cure we mean the removal of the fibroid and survival of the patient; by a roentgenotherapeutic cure we aim only at a clinical cure—the object desired being obtained if the menorrhagia caused by the fibroid ceases, or the fibroid disappears. Recent monographs by Gauss and Friedrich state that in 2,982 cases of fibroid treated with rays there were 95.6 per cent cures and 4.4 per cent failures. In 944 fibroids treated with radium there were 94.4 per cent cures and 5.6 per cent failures.

To accomplish these results the technique must be according to the latest advances, and the therapeutist must not only be familiar with the theoretical and practical principles of roentgenotherapy, but he must have at his disposal a modern *x*-ray apparatus. It should be borne in mind that the effect of *x*-rays on fibroids as well as on climacteric hemorrhages is primarily exerted upon the ovaries. A bloodless castration is thereby produced. *X*-ray or radium should be applied soon after the menstruation. Roentgenotherapy should not be applied in cases of fibroid which extend above the umbilicus. Large pedunculated fibroids are also unsuitable for radiation. Gauss and Friedrich estimate that 70 to 80 per cent of irradiated fibroids shrink in size, one-third disappear entirely. Roentgenotherapy should be applied only in cases in which there is no doubt as to the diagnosis.

L. R. S.

JACKSON, C. The Symptomatology and Diagnosis of Foreign Bodies in the Air and Food Passages; Based upon a Study of 789 Cases. (*Am. J. M. Sc.*, May, 1921, clxi, 625–661.)

An elaborate symptomatology of foreign bodies in the respiratory tract is given. The *x*-ray is hardly necessary or useful in examination of the larynx, the direct examination always being more certain and practically conclusive. Aside from direct examination, the *x*-ray is of great value in examination for the detection of foreign bodies in the trachea and bronchi, and their differentiation from esophageal foreign bodies. Disc-shaped foreign bodies seen in the *x*-ray in the sagittal plane, if lying flat in the postero-anterior view, must be in the esophagus; if seen on the edge in the postero-anterior view the trachea is the site of lodgment. This is on account of the anatomical construction of the trachea with a free space in the cartilaginous rings posteriorly, and likewise because the foreign body must necessarily enter the trachea through the glottis which is in a sagittal plane. The esophagus on the other hand, is a closed, flattened tube lying in a plane perpendicular to it. Roentgenoscopic mixtures can be seen to pass posterior to tracheal foreign bodies and to divide and go around esophageal bodies. Opaque foreign bodies can be easily localized in the bronchi and lungs. Both lateral and posteroanterior plates must be taken to avoid missing any shadow which might overlap the spine or bony structure. Likewise a very thin or flat foreign body might cast an inappreciable shadow in one position and in another view at right angles to it, give quite a distinct shadow.

For distinguishing non-opaque foreign bodies certain roentgenographic findings are mentioned:

1. Increased transparency on the obstructed side of the chest.
2. Displacement of the heart toward the uninvolved side.
3. Downward displacement of the diaphragm and a marked limitation of its motion on the obstructed side.

In short, an acute monolateral obstructive emphysema.

To localize a branch bronchus invaded by a small foreign body the bronchoscopic insufflation of dry bismuth subcarbonate is used. No ill effect has been noted from this method.

Roentgenograms should be made to localize the foreign body before removal and again after removal to discover the possible presence of a second foreign body. Instances are cited where failure to do this would have led to disastrous results.

Where non-opaque foreign bodies are present in the esophagus the administration of opaque media may be used, or a barium-filled capsule may be given. This lodges at the site of the foreign body, slowly dissolving and liberating the barium which surrounds the body. All cases where long standing, obscure chest conditions are present, especially where no tubercle bacilli can be found in the sputum,

should be given the benefit of roentgenographic examination for foreign bodies. A negative diagnosis should not be made except on plates of the very best quality and after fluoroscopic and several plate examinations. All cases, even when foreign bodies can be clearly seen, should be given a thorough physical examination so that the knowledge gained thereby may be utilized in the localization of non-opaque foreign bodies at some future date.

J. E. SUNDER.

CHARLIER. Radiotherapy of Neuritis. (*J. de Méd. de Par.* May 30, 1921, xl, 15).

Since so-called neuritis and allied conditions are a rich field, the possibility of successful treatment by irradiation presents much interest. The idea is by no means new, for in 1908 this treatment was recommended under certain conditions by Babinski and Delherm. The author states in advance that the best results are obtained in paroxysmal neuralgia or neuritis, when the paroxysms succeed one another rapidly. One had better make use of weak doses several times weekly, for moderate and strong radiation may at first aggravate the pain and the small dose may give an equally good result. The author's technique is best shown by repetition of case histories. Thus a woman of fifty-three was first seen in 1908 with a history of neuralgiform crises for the previous three months in the cervicodorsal area. The right shoulder, right side of the neck and upper part of the back were the regions involved. The patient had been treated without benefit by the constant current. The entire region was rayed with 5 H, 1 mm. aluminum filter, at weekly sessions. After five or six sessions the patient appeared to be cured. In a second case of the same sort, treated in 1920, in a woman of thirty-four, 2 H were used, at three séances, filtration aluminum 3 mm., at intervals of two to three days. In this patient the part rayed was the spine—the four first cervical vertebrae. A recurrence was treated with 1 H, 2 doses, and the patient has since been free from attacks. In a severe case of sciatica of long duration—over twenty years—with five separate protracted experiences, the third, fourth and fifth lumbar vertebrae and sacrum were rayed, initial dose 2 H, later ½ H and 1 H. After ten séances the patient recovered completely.

FAURE-BEAULIEU and BECLERE. Rectal Insufflation with Carbonic Acid Gas in Radiologic Exploration of the Liver and Spleen. (*Bull. et mém. Soc. méd d. hôp. de Paris*, February 3, 1921.)

For a number of years various attempts have been made to increase the visibility of the abdominal viscera with special reference to the liver and spleen. In areophagus subjects the contours of these two viscera are notably clarified. The artifice of generating air in the stomach by drinking fluids which effervesce on mixing has not proved meritorious and the insufflation of air into the colon was found to be superior to the preceding, but had one notable disadvantage, which was the tendency of the injected air to remain in the colon, especially in subjects with peritoneal adhesions, organic stenoses, spastic contraction, etc., of the bowel. Artificial pneumoperitoneum is also open to objections such as disturbances of the static relations of the viscera which have exceptionally proved serious. In insufflation the custom has been to employ either atmospheric air or oxygen, neither of which gases is readily absorbed. The author has substituted carbonic acid as having greater absorbability by the intestine. One should secure a tube of compressed carbonic acid of the ordinary commercial type. This may be connected with an oxygen gas bag which serves as a reservoir and from which the carbonic acid is conveyed into the rectum under screen control. It is not necessary to evacuate the colon in advance of the insufflation. The examination must be made rapidly before much of the gas can be absorbed. Cases are narrated which bring out the great advantages of the method.